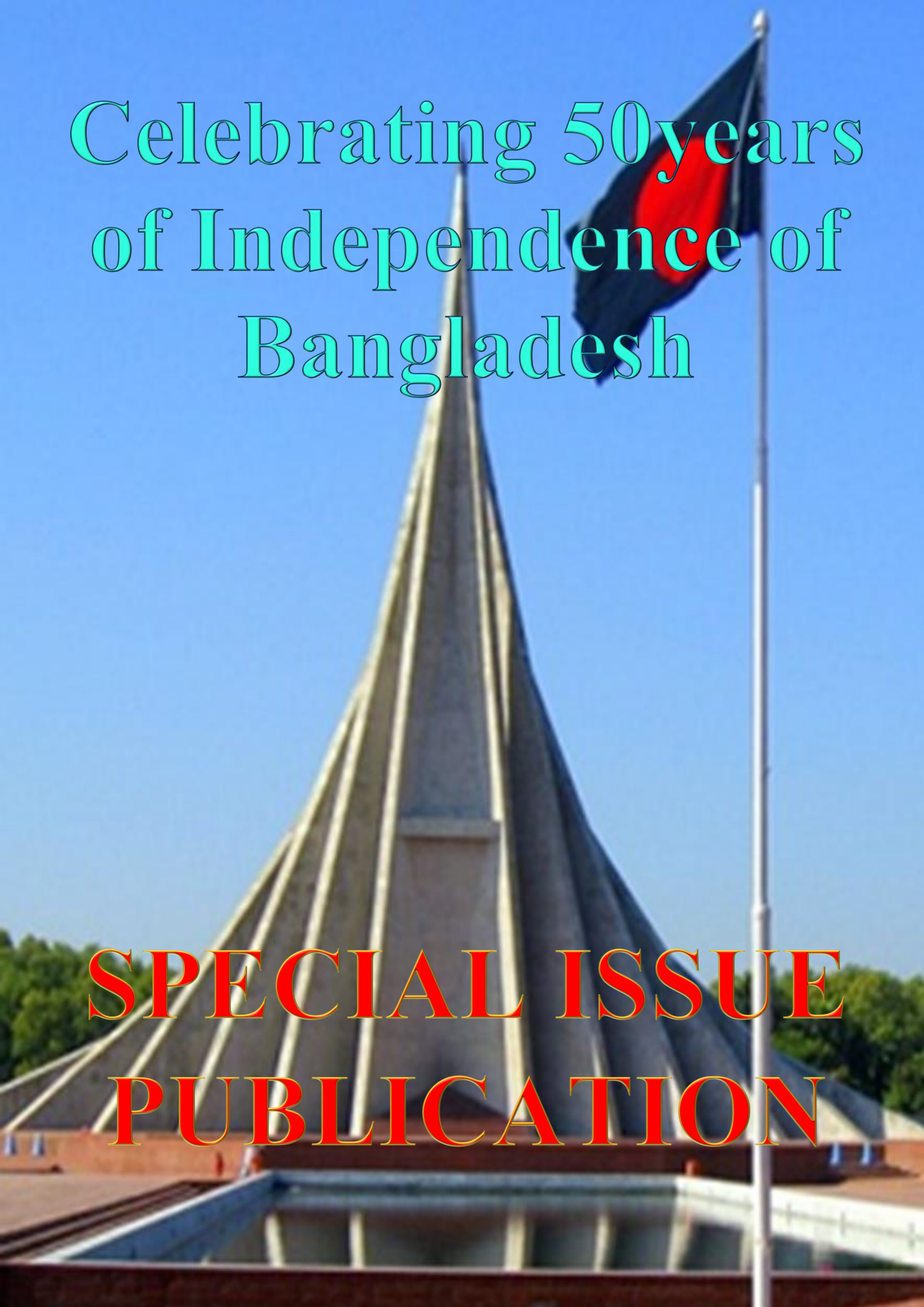
Celebrating 50years of Independence of Bangladesh



SPECIAL ISSUE PUBLICATION

Special Issue Section IV

Sports and Exercise Science Articles

Commemorating 50th year of Independence of Bangladesh - Scholarly Research Investigations

With utmost respect from the core of our hearts, we intend to commemorate the 50th year of Independence of the Great Nation of the People's Republic of Bangladesh by acknowledging the ground-breaking research calibre of the Bangladeshi Research Scientists and Scholars, who kept on delivering with outstandingly innovative experimentations throughout the world. We conceived this special issue to provide a platform to disseminate outcomes of multidimensional research investigations, which have been conducted mostly in universities and research institutes in Bangladesh and neighbouring nations. These highly skilled research scientists of Bangladesh have employed cutting-edge technologies to investigate the complex and yet unexplored aspects associated with diverse areas of life ranging from medical and health issues, cognitive neuroscience, rehabilitation sciences, issues pertaining to motor control, enhancement in sports performance, motor skill limitations influencing overall development among Specially Able Children and factors associated with management of health risk as well.

In this Special issue in Section I, we have included the meta-analytic systematic review studies. These studies have examined impacts of lifestyle on PCO; effectiveness of proprioceptive training on OA limitations; efficacy of differential coordination training regimes on motor deficiencies; and benefits of VMBR and Biofeedback techniques on the performance of athletic skills. Here, the noteworthy fact is that all those meta-analytic investigations have been conducted including almost every of the previously carried out valid and authentic RCTs following rigorous methodology.

Health Science topics in Section - II have encompassed extensive research on exclusively vital current issues associated with the awareness and behavioural manifestations pertaining to the outbreak of COVID19 from a Bangladeshi perspective. Further to that, studies on the impacts of exercise interventions in enhancing health status as well as cognitive functions as the precursor for effective management of Type 2 DM among Bangladeshi individuals and cost-effectiveness of those interventions, are breakthrough investigations that are already universally acknowledged as apex research outcomes. Section III, however, has included studies on cognitive neuroscience aspects associated with neural processing of auditory attention characteristics in dyslexic children, and visual attention and language processing investigated among pregnant women. These studies have been carried out incorporating sophisticated gazettes for the assessment of topographic cortical activation based on ERP and fMRI evaluations. In this section experiments on the rehabilitation sciences are also disseminated. While one case study has reported on the utilization of unique techniques for prosthetic rehabilitation, the other study has been conducted introducing EMG biofeedback and modified isokinetic intervention techniques following rigorous methodology to minimize feelings of pain and perceived stiffness among elderly osteoarthritic patients. Finally, Section - IV has been considered to include investigations on the effectiveness of VMBR and Biofeedback intervention techniques on athletic performance excellence; the impact of motor skill training on complex reaction ability in young-adult individuals having partial dyspraxia. Apart from all those, this section has also included outcomes of an extensive study on Specially Able Children, in which facilitative impact of young athlete (motor skill-oriented) training on tandem walking ability has been thoroughly investigated.

We have critically reviewed (double-blind review) and evaluated all the manuscripts submitted for publication in this issue. The final reviewer has adequately ensured that as per the suggestions of the reviewers, original research submissions have been optimally modified. Thereafter, all the Section Guest-editors of this issue, upholding the core academic and research integrity, have endeavoured to leave no stone unturned to warrant the quality and validity of the research documents accepted for publication. In every section content of the articles are linked with the cited references, which may provide optimal opportunity to the learned researchers. Apart from that, we have also provided back-and-forth links of cited documents, so that the readers can easily check the citations in the list of references and can promptly go back to the area of discussion. We can vouchsafe that we have aspired only to invigorate the academic and research milieu of Bangladesh. This country on the brink of achieving hard-earned independence was proclaimed as the "bottomless basket". I am sure I am not the only one who strives hard to showcase the development of the Nation of Bangladesh, the country having full of enthusiasm. Here I am being the Lead Guest-Editor would like to acknowledge the dedication of all the Guest -Editors and Reviewers for their sincere contributions. I would most sincerely like to thank all of them, who relentlessly took care of their responsibilities to ensure the validity of the research articles and the high academic standard of this issue.

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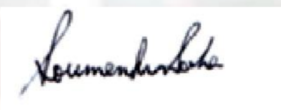

SECTION IV –
Sports and Exercise Science Articles

International Journal of Life science & Pharma Research

MULTIDIMENSIONAL EXTRAPOLATIVE IMPACTS OF MOOD FACTORS ON VMBR AND BIOFEEDBACK INTERVENTIONS FACILITATING AGILITY PERFORMANCE

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KEYWORDS:

Mood, VMBR, Biofeedback, Agility, Predictive influence, Athletics, Performance, Sport skill

ABSTRACT

Background: Elite level athletic performance is universally acknowledged as not consequence of mere tenacious and strenuous practice. As crises from diverse sources may hinder optimal athletic performance, athletes need to adopt relevant and effective psychotherapeutic techniques for regulation of their psychological competence and required for performance excellence.
Aim: Present study was carried out to investigate significance of visuo-motor behaviour rehearsal (VMBR), and biofeedback intervention technique, if any, on psychological (mood parameter) aspect associated with erroneous performance outcomes identified among the athletes.
Method: Thirty-nine promising athletes of Malaysia faced with dismal performance, were recruited as participants, who were subjected to assessment of cardiovascular fitness and autonomic measures of arousal, followed by assessment of mood states, emotional stability, and athletic agility skill. Followed by that, in order to modify their erroneous performance outcomes, athletes were introduced to VMBR and biofeedback training regimes. To verify impacts of psychotherapeutic training regimes Mid-term, post-intervention, and post-follow-up evaluation were carried out.
Results: Repeated measure of ANOVA outcomes revealed that at the post-intervention phase, both VMBR training and composite biofeedback intervention regime were evident as effective enough to improve physical performance indices, especially agility of the athletes. associated with changes in impulsivity and irritability evident among the athletes. No difference between the intervention techniques were evident, and furthermore, this improvement in agility was not found as sustainable. Apart from that, multiple linear regression analyses outcomes revealed differential predictive associations between mood factors and agility performance outcomes, evident among athletes assigned to different experimental conditions.
Conclusions: Both intervention techniques were evident as effective in inducing faster agility performance displayed by the athletes, although no comparative edge between the interventions was confirmed. Athletes of VMBR group perceived lesser fatigue, which along with other mood factors predicted faster agility. For the Biofeedback trainees lesser extent of tension along with other mood variables resulted in faster agility. Athletes of control condition had higher extent of tension and fatigue, which perhaps caused major difficulty in them, and hence they could not display faster agility.

1. INTRODUCTION

Performance efficacy in athletic performance are often evaluated by several relevant indices. This evaluation of aetiological aspects concerning performance deficiencies are supposed to be planned based on investigation on physiological, cognitive-emotional, psychobiological, psychomotor, and physical performance skills. Performance crises, however, must be dealt with application of effective intervention techniques, which facilitate in reduction of dismal performance and lead to performance excellence in athletics.

Researchers dealing with psychological intervening factors behind dismal athletic performance, often relied only on subjective self-report, which if not objectively substantiated, may contain 'response biases'[1]; may be confined to 'Socially Desirable Responding'[2]; 'Acquiescent Responding' and 'Extreme Responding'[3] or sometimes may also be considered as having source of fallible data[4]. Hence, if the self-report assessments are not aptly corroborated with habituation paradigm psychobiological estimation of emotional indices, obtained data cannot provide objective and substantiated etiological evidence.

Experimental studies dealing with disastrous sport performance, for obtaining psychological assistance, usually remain confined to relaxation and imagery techniques. In this study, instead incorporated visuomotor behaviour rehearsal (VMBR) and Biofeedback interventions. Studies conducted on VMBR and biofeedback training have mostly been done on players who engage themselves in simple and close-skill or discrete skill activities. Athletic sport events, however, comprise multiple types of activities, which may vary from simple and complex, discrete, and serial and continuous activities as well.

Overview on Visuo Motor Behaviour Rehearsal (VMBR)

Visuo-motor behaviour rehearsal (VMBR) involves the psychological aspect of configuration of mental image along with feedback from the performance of the physical skill[5], which was evident to enhance performance in a number of sports and ball games, especially involving closed motor skills, including tae-kwon-do, karate[6], basketball[7,8], racquet ball[9], tennis[10], and cricket[11] cross-country running, golf, track and field, gymnastics, and diving[12].

VMBR involves initial relaxation phase followed by visualization of performance and finally performing the actual skill under realistic conditions. In VMBR intervention technique, imagery of performance and performance and actual performance continues alongside each other and provides the athlete with ample opportunity to fine-tune both processes simultaneously. Unless adequate adaptation of perceptual-cognitive processes involved in formation of athletic performance related imagery is ensured, VMBR can be detrimental to performance of motor skill[13-16].

Overview on Biofeedback intervention

Biofeedback interventions on the contrary, enhances mood and by virtue of improvement in cognitive competence[17] resilience and perseverance to perform any task gets increased[18]. In applied psychotherapy Electromyography (EMG - BF), Peripheral Skin Temperature (PST - BF), Heart Rate Variability (HRV - BF), Skin Conductance (Sc - BF), and Electroencephalography (EEG - BF)[19], etc biofeedback techniques are frequently used and investigated. Biofeedback basically replenish the gap between conscious response to novel situation, and resultant peripheral (autonomic) neural activation[20,21].

As the fundamental notion of a feedback loop demonstrates, effectiveness of biofeedback control generally depends on individualistic enhancement in self-regulation or self-control. Thus, owing to this phenomena, some of the athletes are noticeably evident as better capable of decreasing their Sc indices far more easily compared to their counterparts[13,22,23]. Others on the other hand, might take more time to regulate themselves, and to follow the autosensory processes required to monitor their own conditions and simultaneously trying to regulate their Sc indices[24-26]. Introduction of Sc-BF intervention in sport science research following exhaustive methodological considerations are scanty in number[13,22-26], while researchers in sport psychobiology mostly focussed on the facilitative impacts of EEG Alpha & EMG biofeedback interventions on improvement in sport performance, while Sc biofeedback as psychotherapeutic interventions were largely ignored[13,23-31].

Likewise, the EMG biofeedback technique helps the athletes in reduction of somatic anxiety and muscle tension[24,27], and regulates motor capability, muscle activation and the consequent athletic movement efficiency[32]. In enhancing sport performance, EMG guided isometric contractions and relaxation, enables the athletes to learn regulation over their muscular and psychomotor ability and to regulate themselves in actual competitive situations[13,23,25-28].

Sc biofeedback training enhances cognitive competence of the athletes to remain focussed in self-regulation, which magnifies probability of successful training outcomes, while EMG biofeedback intervention boosts up involvement, motivation, and exercise compliance of the athletes, and thus increases the probability of success[33]. For track and field athletes, neuromuscular control and quadriceps strength have been found to increase with the aid of EMG Biofeedback[34-36]. Further to that, significant strength gains were evident in research using isometric exercises coupled with EMG Biofeedback[37-39].

With such a background the present study intended to identify the integral processes involved in VMBR, which may have deductive cognitive-emotional contributions on configuration of mental images, facilitating performance of physical skill[5]. Apart from that comprehension of intricate relationship between perceptual-cognitive and motivational aspects along with psychobiological habituation, as that is possible by combined introduction of Sc and EMG biofeedback technique, also demand careful attention[13-16]. Finally, hypothesized differential roles of subjective feelings of mood changes[15] as determinants for performance changes among young-adult promising athletes in Malaysia could be extrapolated.

2. METHODOLOGY

Altogether 39 young adult male athletes (age-range 19 - 22 years; $\bar{x}$ = 20.68 and σ = 1.642) were recruited. Employing Research Randomizer Software[40], athletes were equally categorized into following groups – 1) Group A – No-intervention or control group (n = 13); 2) Group B – Experimental Group I, who received VMBR training (n = 13); 3) and Group C – Experimental Group II, received composite biofeedback intervention technique (n = 13), which comprised of combined introduction of Sc and EMG biofeedback aspects. Allocation of the participants into different groups was concealed, and all the intervention sessions were supervised by qualified therapist.

2.1 Present Study Procedures

For this study ethical approval was obtained from the ethical committee (hereafter the Research Platform) of Universiti Sains Malaysia (Ethical Permission - USM/JEPeM15060224**)**. The experimenter herself was initially attached as a trainer of athletics with the athletic training centre at the SMK Putera Kelantan campus, run by Majlis Sukan Negara in Kota Bharu, Kelantan. Eventually, she got herself associated with the MSN Terengganu as well. Thus, the experimenter could have a prior discussion with the fellow coaches associated with Majlis Sukan Negara; coaches attached with SMK Putera, Kota Bharu, Kelantan and also with the athletics trainers and fellow coaches of MSN Terengganu as well.

For these study participants were subjected to evaluations of Brunel Mood Scale; Heart Rate and VO_2max, and assessment of basic athletic skills, viz., speed, endurance and agility were carried out. Agility was evaluated following specific test for the track-and-field athletes[41-43], was conducted in which athletes are exposed to run 10 meters back and forth, for three times. For this experiment, athletes got three chances, and out of the three fastest score was considered as the agility score[41-43]. Participants of experimental conditions were subjected to the training sessions in the fully equipped and methodologically sound laboratory of Dept. of Exercise and Sports Science, PPSK, USM. Group wise respective interventions, i.e. VMBR training and biofeedback training intervention were imparted following an identical protocol (15 min.s/day, 2 days/week for 10 weeks) (details available at: http://dx.doi.org/10.13140/RG.2.2.21756.05767). All of the participants of Gr. B and Gr. C were imparted therapeutic training sessions in their respective areas of intervention under the supervision of the experimenters. Training sessions for the initial 10 weeks were scheduled for 15 minutes, and for the next 10 weeks, as the difficulty levels progressed, sessions continued for 20 minutes per day. Control Group participants were not exposed to any of the therapeutic interventions. Mid-term assessment was carried out after 5 weeks, i.e., after training of 10 sessions, and post-intervention assessment was conducted after accomplishment of 20 sessions of intervention. Subsequently, after 10 more weeks of no intervention, post-follow-up analysis was also carried out.

3. RESULTS

Reports on descriptive statistics however provided the basic information on the nature of data, which included the reports on centralised tendency and normality of the data and the measures of variability, related to brief information on descriptive analyses (Refer to Table 1). Thereafter the results of the main study are presented, in which the reports on Repeated Measure of ANOVA were detailed.

In the Table 2 pairwise comparisons of each variables observed amongst different groups of participants across different phases were presented. Precisely, to avoid the problems pertaining to space-constraint, only the most explanatory tables on pairwise comparison, which was observed amongst different groups of participants across different phases were presented and outcomes of the repeated measure of ANOVA were presented in this section and those were duly explained based on outcomes represented in those tables. The next tables (viz., 3, 4 and 5) represented outcomes of multiple linear regression analyses, which were carried out to explain interrelationships between differential predictor and dependent variables.

Table 1- *Descriptive Statistics on agility performance score*

Phases	Intervention Groups	Mean	SD	N
Pre-Intervention Agility Scores	Control	13.5046	.34806	13
	VMBR Trainees	13.4546	.46274	13
	Biofeedback Trainees	13.4731	.37659	13
Mid-Term-Intervention Agility Scores	Control	13.5931	.60412	13
	VMBR Trainees	13.1826	.71688	13
	Biofeedback Trainees	13.1040	.49940	13
Post-Intervention Agility Scores	Control	13.1968	.40565	13
	VMBR Trainees	12.7047	.48243	13
	Biofeedback Trainees	12.4029	.24981	13
Agility Scores - Follow-Up Phase	Control	13.6318	.60546	13
	VMBR Trainees	13.0722	.66119	13
	Biofeedback Trainees	13.3070	.47894	13

Table 2

Pairwise Comparisons of AGILITY parameter scores observed amongst different groups of participants across different phases

Measurement Sessions		Groups	Mean Difference	SE	P Value	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Pre-intervention Phase	Control	VMBR Trainees	.050	.161	1.000	-.394	.494
		Biofeedback Trainees	.032	.161	1.000	-.412	.475
	VMBR Trainees	Control	-.050	.161	1.000	-.494	.394
		Biofeedback Trainees	-.018	.161	1.000	-.462	.425
	Biofeedback Trainees	Control	-.032	.161	1.000	-.475	.412
		VMBR Trainees	.018	.161	1.000	-.425	.462
Mid-intervention Phase	Control	VMBR Trainees	.410	.245	.603	-.264	1.085
		Biofeedback Trainees	.489	.245	.310	-.186	1.164
	VMBR Trainees	Control	-.410	.245	.603	-1.085	.264
		Biofeedback Trainees	.079	.245	1.000	-.596	.753
	Biofeedback Trainees	Control	-.489	.245	.310	-1.164	.186
		VMBR Trainees	-.079	.245	1.000	-.753	.596
Post-intervention Phase	Control	VMBR Trainees	.492*	.159	.020	.054	.930
		Biofeedback Trainees	.794*	.159	.000	.356	1.232
	VMBR Trainees	Control	-.492*	.159	.020	-.930	-.054
		Biofeedback Trainees	.302	.159	.383	-.136	.740
	Biofeedback Trainees	Control	-.794*	.159	.000	-1.232	-.356
		VMBR Trainees	-.302	.159	.383	-.740	.136
Post-Follow-up Phase	Control	VMBR Trainees	.560	.232	.117	-.078	1.197
		Biofeedback Trainees	.325	.232	1.000	-.313	.962
	VMBR Trainees	Control	-.560	.232	.117	-1.197	.078
		Biofeedback Trainees	-.235	.232	1.000	-.872	.403
	Biofeedback Trainees	Control	-.325	.232	1.000	-.962	.313
		VMBR Trainees	.235	.232	1.000	-.403	.872

Outcomes of pairwise comparison of the data are reported in the Table 2, and the post hoc pairwise comparison using the Bonferroni correction revealed that at the post-intervention phase of evaluation, significant differences in the agility parameter score were evident between the control group and the intervention groups, viz., the VMBR intervention group ($p < 0.020$) and biofeedback intervention ($p < 0.000$). The post-follow-up level of evaluation reports, however, did not reveal any such differences between control and the intervention training groups. To reiterate, the outcomes of multiple linear regression analyses are presented in this sub-section, which comprised of outcomes associated with the impacts of different mood state factors on the data obtained on dependent measures of agility performance parameters. Based on the multiple linear regression analyses outcomes, differential impacts of various mood state factors, across the individuals representing different intervention groups, are presented.

Table 3

Model a - Summary of multiple linear regression analysis, explaining changes in Agility Scores as predicted by the measures of mood states observed at the post-intervention phase of analyses amongst the athletes in Control condition

Model *a:* Dep. Variable - Post-Intervention Agility Scores	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Intercept)	4582.650	616.365		7.435	.000					
Tension	-26.597	12.615	.622	2.108	.073	.231	-.623	-.452	.528	1.893
Depression	14.077	4.538	.848	3.102	.017	.344	.761	.665	.616	1.623
Vigour	-7.987	3.389	-.715	-2.357	.051	-.053	-.665	-.505	.500	2.001
Fatigue	-23.243	10.454	.575	2.223	.062	.346	-.643	-.477	.688	1.455

[a]{F (4, 8) = 8.275, P < 0.006), Adj. R^2 = 70.8%}.

In Table 3, the model ***a*** emerged significant as the measures of mood states, viz., Tension, Depression and Anger evaluated in the pre-intervention phase, together could explain 70.4% variance of changes in the extent of post-intervention outcome of agility performance scores. Model ***a*** explained the direct relationship between depression and the extent of agility observed in the athletes. Apart from that, inverse relationships between tension, vigour and fatigue scores and extent of agility were also evident.

Table 4

Model b - Summary of multiple linear regression analysis, explaining changes in Agility Scores as predicted by the measures of mood states observed at the post-intervention phase of analyses amongst the VMBR trainee athletes

Model *b*: Dep. Variable - Post-Intervention Agility Scores	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Intercept)	16.087	1.948		8.258	.000					
Depression	-.086	.047	-.524	-1.840	.099	-.222	-.523	-.432	.680	1.471
Vigour	-.039	.016	-.576	-2.394	.040	-.485	-.624	-.563	.954	1.048
Fatigue	.047	.023	.593	2.039	.072	.182	.562	.479	.654	1.529

^{b}{F (3, 9) = 4.537, P < 0.046), Adj. R^2 = 33.7%}

In Table 4, the model ***b*** emerged significant as the measures of mood states, viz., depression, vigour and fatigue evaluated in the pre-intervention phase, together could explain 33.7% variance of changes in the extent of post-intervention outcome of Agility performance scores. Model ***b*** explained the inverse relationships between depression and vigour score and the extent of agility observed among the participants at the post-intervention phase. Apart from that, direct relationship between fatigue and extent of agility was also evident.

Table 5

Model c - Summary of multiple linear regression analysis, explaining changes in Agility Scores as predicted by the measures of mood states observed at the post-intervention phase of analyses amongst the Biofeedback trainee athletes

Model *c*: Dep. Variable - Post-Intervention Agility Scores	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Intercept)	19.205	2.833		6.779	.000					
Tension	.076	.018	.681	4.208	.002	.651	.814	.661	.941	1.062
Depression	-.087	.030	-.464	-2.890	.018	-.292	-.694	-.454	.956	1.045
Anger	-.128	.049	-.415	-2.610	.028	-.479	-.656	-.410	.974	1.027

^{c}{F (3, 9) = 10.509, P < 0.003), Adj. R^2 = 70.4%}.

In Table 5, the model ***c*** emerged significant as the measures of mood states, viz., tension, depression and anger evaluated in the pre-intervention phase, together could explain 70.4% variance of changes in the extent of post-intervention outcome of agility performance scores. Model ***c*** explained the direct relationship between tension score and the extent of agility observed in the athletes. Apart from that, inverse relationships between depression and anger score and extent of agility were also evident.

4. DISCUSSION

Outcomes of the repeated measure of ANOVA (refer to Table 2) depicted that at the postintervention phase of analysis, both VMBR and biofeedback intervention techniques were evident as effective in inducing faster agility performance observed among the athletes, which revealed effectiveness of both of the intervention techniques in improving agility performance. Beneficial impact of VMBR intervention got evidentially confirmed and substantiated by the previous works of Zahir and her colleagues[15]. Further to that, Silmani and the coresearchers[44] in their systematic review pointed out that different types of visualization training methods had facilitative impacts on improvement in agility performance.

Similarly, facilitative impact of biofeedback intervention was similarly got supported by the previous investigations conducted on similar athletic population, following identical research paradigms[11,13,15]. Etiologically it could be hypothesized that, composite biofeedback perhaps enhanced autonomic competence and peripheral neural regulation, which induced faster control over bilateral movements, and resultant faster agility performance evident among athletes[45,46].

Even though both intervention techniques were evident as effective in facilitating faster agility performance, no comparative difference between the intervention techniques got confirmed. Hence etiological analysis on the intricate processes, through which those developments in performance were achieved, could not be ascertained. Further to that, we also intended to investigate on probable reasons behind lack of sustainability of effectiveness of both of the intervention techniques employed.

At this juncture, we attempted to pay in-depth attention to the subjective emotional make-up of the athletes, and hence we focused onto the mood changes. Here we specifically intended to explore on the mediator or moderating roles of pre-existing levels of mood factors on performance of the athletes, who were assigned to different intervention conditions. For this, we strived to investigate on the predictive contributions of various mood factors on the post-intervention level hypothesized improvement in agility performance evident among athletes, who received differential intervention training. Multiple liner regression analyses were carried out separately according to control and different intervention groups, and outcomes, however, revealed interesting explanatory relationships.

Outcomes from the Table 3 clarified unique contribution of depression on the agility score evident among the athletes of the control group, which was obtained at the post-intervention phase of evaluation. This direct relationship further explained that, independent of and excluding the effect of all other predictor variables, lower extent of depression had direct influence on faster agility score evident among these athletes. Relatively higher tolerance index observed in collinearity statistics suggested that, moderately high extent of (61.6%) variance in depression perceived by the participants was not predicted by their perceived extents of tension, vigour, and fatigue scores. This model further explained that every 1% decrease in depression perceived by the athletes would lead to .848% faster agility (refer to Beta Coefficient of depression, having 61.6% of tolerance**)**.

Further to that, inhibitive influence of tension, fatigue, and vigour evident among the athletes of the control group implied that those who had relatively higher feelings of tension, fatigue, as well as vigour, they were evident as capable of producing relatively faster agility compared to their counterparts having lesser tension and fatigue, and lower level of vigour. Thus, findings from this Table 3 implied that among the athletes of the no-intervention or control condition, those who perceived lesser extent of depression, and had relatively higher extent of feelings of tension, fatigue, and vigour, they could display faster agility. Here depression emerged as the most important predictor for agility performance, which implied that, if athletes feel lesser extent of depression, irrespective of their level of tension, fatigue, and feelings of vigour, they can display faster agility.

Outcomes also raise the question that, both higher extents of tension and fatigue were evident to predict changes in agility, which certainly would have detrimental effects on agility. Hence, this model, however, also emphasized significance of introduction of psychological skill training interventions in ensuring peak agility performance[25,26,47-50]. These investigations were conducted on identical population, following rigorous methodology, and hence, outcomes of those studies could be considered as benchmark for psychological skill training in improving athletic performance among south-east Asian population.

Findings from Table 4 clarified unique contribution of fatigue on the agility score evident among the VMBR trainee athletes, which was obtained at the post-intervention phase of evaluation. This direct relationship further explained that independent of and excluding the effect of all other predictor variables, lower extent of fatigue had direct influence on faster agility score evident among these athletes. Relatively higher tolerance index observed in collinearity statistics suggested that, relatively high extent of (65.4%) variance in fatigue perceived by the participants was not predicted by the feelings of depression and vigour reported by the athletes. This model further explained that every 1% decrease in fatigue evident among the athletes would lead to .593% faster agility (refer to Beta Coefficient of fatigue, having 65.4% of tolerance).

Apart from that, inhibitive influence of both depression and vigour evident among the athletes of VMBR training group implied that those who reported to have relatively higher extent of feelings of vigour as well as depression, they were evident as capable of producing relatively faster agility compared to their counterparts having lower levels of vigour and depression. Thus, findings from this Table 4 implied that among the athletes of VMBR group, those who perceived lesser extent of fatigue and had relatively higher extents of feelings of vigour as well as depression, they were evident to display faster agility. Here the question arose with association between higher extent of depression and faster agility. Even though higher extent of vigour was evident as one of the predictors for faster agility, higher level of feelings of depression would have detrimental effects on performance. As the previous studies on identical experimental set-up and sample postulated[48,50,51] VMBR intervention although enabled the players and athletes to enhance their performance, perhaps could not modify transient emotional and mood aspects, which could have significant extrapolative influences on skilful athletic performance.

Outcomes of the Table 5 clarified unique contribution of tension on the agility score evident among the biofeedback trainee athletes, which was obtained at the post-intervention phase of evaluation. This direct relationship further explained that independent of and excluding the effect of all other predictor variables, lower extent of tension had direct influence on faster agility score evident among these athletes. Higher tolerance index observed in collinearity statistics suggested that, very high extent of (94.1%) variance in tension perceived by the participants was not predicted by their depression and anger scores. This model further explained that every 1% decrease in tension perceived by the athletes would lead to .681% faster agility (refer to Beta Coefficient of tension, having 94.1% of tolerance**)**.

Besides the previous analyses, inhibitive influence of both depression and anger evident among the athletes of this group implied that those who had relatively higher extent of feelings of depression and anger, they were evident as capable of producing relatively faster agility compared to their counterparts having lower depression and anger. Thus, findings from this Table 5 implied that among the athletes who received biofeedback training, those who perceived lesser extent of tension, but had relatively higher extents of depression and anger, they could display faster agility. As it was viewed among athletes of both the control and VMBR intervention groups, differential roles of negative[52,53] and inhibitive mood factors[26,48,52] on performance were evident in this group as well.

Thus, findings of this research hinted up on significance of considering emotional and psychobiological, especially autonomic make-up of the athletes, which however, got substantiated by the outcomes of several of the previous investigations[26,47,53,52] on athletes, which were conducted under identical methodological set-ups, and following similar intervention protocols as well. These researchers in by and large highlighted improvement in emotional make-up of the players, as facilitated by reduction of irritability, somatised anxiety, and transient subjective feeling of anxiety, anger and feeling of fatigue[26,47,52,53].

Even though contributions of mood factors were evident, which got corroborated by previous research findings as well, functional contributions of the aforementioned mood factors, should be judged with careful attention, as those were subjective self-report data, which are basically situation-specific or transient data, which are susceptible to have subject-relevant variability and situation-relevant lacks in consistency as well. As these issues are being held for quite a few decades, these subjective self-reports, if not objectively authenticated, may contain 'response biases'[1]; may be restricted to 'Socially Desirable Responding'[2]; 'Acquiescent Responding' and 'Extreme Responding'[3] or may also be considered as having sources of fallible data[4].

In sum, this study recommends adequate evaluation of emotional make-up of the participants, undergoing differential intervention training. More so, this study also suggests inclusion of transient mood factors as independent predictors for performance, while those transient factors should be accompanied by inclusion of inner core emotionality. Further to that, these subjective transient and dispositional and inner core emotionality factors must be adequately corroborated by simultaneous and real-time evaluation of objective psychobiological indices as well.

5. CONCLUSION

Outcomes of this study prompted us to conclude that both the intervention techniques induced faster agility performance displayed by the athletes, although the difference between the interventions was not evident. Athletes assigned to different groups had differential pre-existing mood states, which perhaps contributed to their agility performance. Athletes of control condition predominantly had negative and inhibitive moods viz., tension, fatigue and depression, which might have hindered their agility performance. Athletes of both VMBR and Biofeedback intervention groups had high feelings of depression and had vigour and anger. Besides, VMBR trainees perceived lesser fatigue, while their counterparts in the biofeedback group perceived a lesser extent of tension. Finally, the action oriented VMBR training could have reduced the feelings of depressions, could utilise the feelings of vigour in the desired direction and produced faster agility performance. The biofeedback training perhaps reduced the feelings of depression, anger and could reduce the feelings of tension, and enabled the athletes to perform the agility tasks faster.

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7. CONTRIBUTION OF AUTHORS

Conceived and designed the experiments: SoS, SrS
Collected data and performed the experiments: FaS, FoH, MaA, SoS, SrS
Contributed with materials/analysis tools: SrS, SoS, HaH
Analysed the data: FaS, SoS. SrS
Wrote the manuscript: SrS, SoS
Checked and edited the format of the paper: SoS, SrS, HaH, FaS
Final approval: SoS, SrS, HaH

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PROBABILISTIC INFLUENCE OF MOTOR SKILLS ON TANDEM WALKING IN SPECIAL OLYMPICS PROGRAM CHILDREN IN BANGLADESH

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Mood, VMBR, Biofeedback, Agility, Predictive influence, Athletics, Performance, Sport skill

ABSTRACT

Background: Children with developmental deficiencies need early intervention, which modify their awareness about themselves, body-image, awareness of strength, flexibility, coordination, and about their surroundings as well. These modifications lead to improvement in motor and social skills, and wholesome development.

Aim: This study intended to explore into efficacy of Young Athletes intervention program developed and organised by the Special Olympic International (SOI), in order to develop motor skills in children diagnosed with intellectual deficiency (ID).

Method: Present study was conducted in Bangladesh, following experimental design and protocol provided by SOI, funded by IKEA, supervised by the Asian Institute of Technology (AIT), and carried out by the experts of Special Olympics Bangladesh (SOBD). Children registered with SOBD (n = 420), aged between 4 to 7 years, who were diagnosed as having ID, were categorised into three different groups, viz., control group, cohort 1 (C1) and continuous survey (CS) group. Thereafter, all of the children were subjected to baseline evaluation of motor skill components, viz., walking, balancing, carrying materials etc. Followed by that, children of C1 and CS groups were introduced to YA activity training (1 hour/week guided training by SOBD experts, and daily practice of those skills for one hour) for 8 weeks. After 8 weeks, post-intervention assessment on the aforementioned motor components were carried out to verify impact of YA training on children of CS and C1 groups.

Results: Baseline descriptive analysis revealed dissimilarity in Tandem Walking performance scores evident among children of three different groups. Post-intervention analyses revealed no impact of YA activity. Children of both Control and CS groups were evident have similar baseline tandem walking scores, which got marginally improved after 8 weeks of YA training in both of the groups, although children of Control group did not receive any training. Children of C1 group, however, had very poor baseline Tandem walking score, which evidentially got improved after 8 weeks of YA training. Outcomes of multiple linear regression relationships revealed differential predictive relationships.

Conclusions: No improvement in tandem walking performance was evident. Regression analyses mostly hinted up on the pre-existing walking and balancing ability of the children, which facilitated improvement in tandem walking after 8 weeks of YA training.

1. INTRODUCTION

Children at their pre-school age, generally learn from their surroundings, and if provided with ample opportunity to imitate others, they can do that spontaneously. Regardless of their level of cognitive efficiency and enrichment or developmental deficiency, this phenomena is obvious for children all over the world. Numerous authentic studies on impacts of motor skills training by engaging children with intellectual deficiency (ID) confirmed that early intervention of structured motor skills training significantly improve emotional regulation, learning efficiency, enthusiasm, and confidence[1-5]. Outcomes of these studies provided authentic grounds to the Special Olympic International to design and implement a therapeutic platform based on psychomotor development-oriented[6,7] interventions, tailored for children with or without ID at their early (0 - 3 years)[6] stages of gross and fine motor development. As those researchers confirmed, fundamental motor skills training at earlier ages ensure unique enhancement in motor and cognitive performance, and in consequence psychosocial adaptations as well.

With such a conceptual background, the Special Olympic International (SOI) conceived the Young Athlete training program, which comprises of training of fundamental skills which enable children to become aware of themselves, their body-image, awareness of strength, flexibility, coordination, and endurance, which are important for unique development of motor and social skills, and wholesome growth. Empirical evidence claimed that participation in Young Athletes (YA) program of SOI significantly enhances mood, improve self-confidence, strengthens interpersonal relationships, in familial set ups and in community as well, which in turn improve parental aspiration for their children with ID[1 - 4]. Children with ID need multifaceted supports to augment their growth to achieve essential developmental indicators at early ages, and hence traditional SOI sports program, which were only available to children aged 8 and over, would not suffice. Unlike other structured therapeutic regimes, YA training is easy learn and to implement and most importantly it is very much enjoyable and exciting for the learner children, especially with ID. Apart from that, YA training can be executed at home, in schools and community set-ups as well, and for that only basic equipment and the YA Activity Guide are required. As SOI postulated, following YA activity regimes, children would learn healthy habits at very earlier age. These effective methods would ensure healthy lifestyle throughout their life, sense of camaraderie (community awareness and socialization), and finally the interest in learning newer skills and concepts. Precisely, YA activities provide ample opportunities to imitate playing behaviour, which facilitate the conceptual basis for playful social communications and developmental adaptation of crucial learning skills. Children with ID are supposed to learn to communicate, to realize the sense of sharing[8], waiting for their turns by not being hasty[9] and reckless[10], and to follow directives. These all help the children to transform from all-pervasive sense of disinhibition to conformed[11] family, school, and community behaviour.

Besides the concern for adequately acceptable intervention techniques, evaluation of the level of motor skill and coordination in children with ID, was also of a debatable issue. Researchers involved in investigating performance hindrances in motor coordination, motor activity contexts by-and-large focussed on identification of intrinsic determinants of dismal performance outcomes either only based on subjective self-report indices, which are susceptible to lack in consistency, validity and reliability or on the basis of survey from parents and care-givers, which may not be able identify the intricate issues pertaining to perceptual-motor limitations and the resultant deficiencies in cognitive and social skills[12-14]. In order to minimize these complications, SOI authority for their research on impact of YA activity on motor skill and all other adaptive behavioural indices, decided to employ modified version of the Vineland ABS- II, i.e., Vineland Adaptive Behaviour Scales-Second Edition (Vineland-II), which evaluates human adaptive behaviour from birth to age of 90 years[15]. One of greatest advantage of Vineland Scale is that it provides opportunity to assess five main domains, viz., Communication, Daily Living Skills, Socialization, Motor Skills, and Maladaptive Behaviour, which enables researchers to investigate impacts of interventions on various service delivery models, viz., family, school and community[16].

With such a background, the present study explored into the question of developmental limitations observed amongst the children with ID based on deficiencies in motor and movement skills. Precisely impacts of YA training on motor performance indices were evaluated based on adopted version of Vineland scale[15,16]. YA being a sport and play program to prepare young children with intellectual disability (ID) to participate in sport activities when they grow up, the aim of this research was to validate YA activities and determine the impact made on the child in basic sport skills, social skills, and skills for daily living.

2. METHODOLOGY

Special Olympic International (SOI) intended to conduct a longitudinal research investigation on impacts of Young Athletes (YA) training on the extent of deficiency in selected motor skills evident among children diagnosed with ID. This study was globally funded by the IKEA Foundation and was planned and pre-designed by the SOI authorities. Thus, this study was considered as SOI-IKEA-YA research program, which was supervised by the Asian Institute of Technology (AIT), and in Bangladesh entire research program was conducted by SOBD (Special Olympics Bangladesh) Research team.

2.1 Participants

For this study, four-hundred twenty Bangladeshi children diagnosed with intellectual disabilities (ID) were chosen as participants, who were screened following identical selection criteria (they had IQ level below 70-75). These children were aged between 4 to 7 years ($\bar{x}$ = 5.68 and σ = 1.19) and were registered with the SOBD as Special Children.

2.2 Materials Used

In this experiment, for evaluation of motor performance skills, following materials were used:

a. Measuring tape
b. Stopwatch
c. Masking tape (for making a line on the floor for walking and running activities), and
d. Walking and Balancing evaluation protocols (provided by SOI)

2.3 Randomized Group Assignment

At first, children who were registered with SOBD as Special Children were considered eligible as participants. Among them, according to SO Program's YA registration records, those who were included in this longitudinal study in the 1st quarter of 2018, were considered as the first cohort of participants. Altogether 420 children, who met the inclusion criteria were included in the program as Cohort 1 participants. Thereafter, by employing the Research Randomizer Software[17], these children were categorized into following three groups – 1) Control group (n = 89); 2) Experimental Group I, i.e., the Continuous Survey Group (CS) - those who were supposed to be part of the longitudinal study as Continuous group and were supposed to receive YA training for 80 (n = 88); 3) and Experimental Group II, the remaining children of the Cohort 1 (n = 243), who received YA intervention for a period 20 weeks only. These children of Exp. group II were considered as Cohort 1 (C1) children. Allocation of the participants into different groups was concealed, and all the intervention sessions were supervised by qualified therapists.

2.4 Present Study Procedures

Ethical approval for this study was obtained from the Research Platform of Bangladesh Institute of Sports Science (Ethical Permission - BISS/Res.-Intl. SOBD -321 - 03/2017). SOBD authorities sent concealed appointments to all the participants (in this case guardians or caregivers of the special children) to arrive at the SOBD research venue at the SOBD office premises on the pre-scheduled and specific allocated dates and times. These children and their guardians were already briefed by the SOBD officials and volunteers regarding the purpose of the study, and responsibilities of the guardians, time-constraints etc, and all other necessary affairs as well. Signed consent on behalf of the special children were obtained from their guardians/parents/caregivers, and they were adequately compensated for their time engagement and the resultant constraints, if any.

Thereafter as per schedules, baseline evaluation of selected motor skill components were carried out. For these assessments, children were prepared (rapport were established), and the assessors were kept blinded. Following the SOI-IKEA-AIT-YA research implementation guidelines, for this experiment two types of balancing and walking abilities were evaluated. These evaluations were conducted as per the guidelines provided by the SOI (which was prepared following Vineland - II[15]). At first balancing ability was evaluated, and for this two sub-components, viz., ability to stand on one foot and the ability to stand on tiptoes were considered as the indices. These evaluations were carried out following the prescribed standardised protocols[15] and children were provided with adequate intervals/rest periods between the assessments, as per the situational requirements (uniformity was maintained).

For the assessment of balancing ability, children were subjected to stand on one foot (one-by-one both right and left foot), and duration of their ability to stand on one foot was recorded by the evaluator as the data for that balance sub-component. Apart from that, duration of their ability to stand on tiptoes was also recorded (other sub-component of balancing ability). Thereafter, one-after-another three sub-components of walking ability were evaluated. First of all, ability of the children to walk on a line, i.e., stepping in a straight line, by attempting and placing both the feet on the line, with the front foot (irrespective of either the left or right foot) placed such that its heel touches the toe of the standing foot, which is referred as the tandem walking ability, was evaluated. Here, the indices such as how many feet (1 or 2) were placed on the line, and how far the children could walk, i.e., how many steps were taken by the children, were considered as the data for this study. Alike that, ability of the children to walk carrying any medium-sized object, and their ability to demonstrate walking sidewise were also evaluated. In both of the cases, distance covered by the children were recorded as the data for the study.

Thereafter, children assigned to Cohort 1 (C1) and Continuous Survey (CS) groups were introduced to the YA activity training (1 hour/week monitored training by SOBD experts, and practice of those skill for 1 hour on every morning, at school/home/community set-ups), comprised of exercises on foundation skills; walking and running; balance and jumping drills; trapping and catching; throwing; striking and kicking skills training[15]. Children of the control condition were not exposed to any such training and, they were closely monitored by the researchers and the expert trainers of SOBD, so that they abstain themselves from engaging in some such activities on regular basis. Precisely the guardians/parents/caregivers of those children were advised, not to keep them engaged in any such regularised activity regimes. After 8 weeks of YA training, following exactly similar assessment protocols, children of all the groups were subjected to post-intervention evaluation of all of the baseline assessment indices. Here it is worthy to be mentioned that this research was carried out as per the guidelines provided by the SOI, and the participants (hereafter the special children) were recruited based on the stringent inclusion criteria of SOI, and they were randomly assigned to different groups, and baseline analyses on selected motor skills parameters were carried out, but no baseline similarity of the participants could be ensured. Precisely, this research was carried out as retrospective cohort study, following subject-own-control and causal-comparative design, conducted in within-subject experimental format. Hence, baseline dissimilarity although evident, outcomes could be analysed based on subjects served as their own control format. Further to that, in order to have better understanding on the relative impacts of YA training and no-training conditions, we decided to analyse predictive influence of contributing factors on the dependent measures evident among the children.

3. RESULTS

Descriptive information on Motor Skill Assessment Scores evident among children assigned to different groups are presented in the table 1. Outcomes in this table depicted baseline dissimilarity and considerably higher extent of variability. Apart from this table outcomes of the pairwise comparison (refer to table 2) and findings of multiple linear regression analyses are detailed in the tables 3, 4 and 5.

Table 1 - Descriptive Statistics on Motor Skill Assessment Scores Across the Different Groups and Measurements

	Children assigned in different groups	Mean	Std. Deviation	N
Pre-int. Walking (tandem walking)-How far was the child able to walk with 1 or 2 feet on the line?	Control Group	9.4607	4.82431	89
	Cohort Group 1	5.7284	4.65596	243
	Continuous Survey Group	9.1591	5.84844	88
	Total	7.2381	5.25897	420
At 8th week Walking (tandem walking)-How far was the child able to walk with 1 or 2 feet on the line?	Control Group	11.2584	4.23870	89
	Cohort Group 1	9.9712	4.73024	243
	Continuous Survey Group	10.9205	5.96970	88
	Total	10.4429	4.94109	420

Table 2 - Pairwise comparisons of Motor Skill Assessment Scores observed amongst different groups of children across different phases

Measure: Tandem Walk

Phase	(I) Children assigned in different groups	(J) Children assigned in different groups	Mean Difference (I-J)	Std. Error	Sig[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	Control Group	Cohort Group 1	3.732*	.615	.000	2.254	5.210
		Continuous Survey Group	.302	.746	1.000	-1.492	2.095
	Cohort Group 1	Control Group	-3.732*	.615	.000	-5.210	-2.254
		Continuous Survey Group	-3.431*	.617	.000	-4.915	-1.947
	Continuous Survey Group	Control Group	-.302	.746	1.000	-2.095	1.492
		Cohort Group 1	3.431*	.617	.000	1.947	4.915
2	Control Group	Cohort Group 1	1.287	.610	.106	-.178	2.753
		Continuous Survey Group	.338	.740	1.000	-1.440	2.116
	Cohort Group 1	Control Group	-1.287	.610	.106	-2.753	.178
		Continuous Survey Group	-.949	.612	.365	-2.421	.522
	Continuous Survey Group	Control Group	-.338	.740	1.000	-2.116	1.440
		Cohort Group 1	.949	.612	.365	-.522	2.421

Outcomes in the Table 2, revealed baseline dissimilarity or pre-intervention difference in the level of tandem walking task performance observed among children, who were assigned to three different groups. At the pre-intervention phase, difference between the control and cohort 1 group, and between cohort 1 and continuous survey group were evident. Findings on post-intervention analysis, however, did not reveal any difference between the groups, and between the phases as well. Thus, any impact of YA training regimes on the children of the two experimental groups could not be ascertained. Here, we decided to evaluate outcomes based on predictive relationships. It was hypothesized that some interrelated motor and movement skill factors might have contributed on the changes on tandem walking performance evident among the children, after 8 weeks of YA intervention training.

As huge dispersion in the descriptive reports were evident, we could realise that the data were heterogeneous in nature, which led to pre-intervention level difference in tandem walking performance scores evident between the groups. These dissimilarity had the bearing on post-intervention scores, and hence the impacts of YA training, if any, could not be ascertained. These scenario of heterogeneity in the baseline data, and the relative impacts on the post-intervention outcome is clearly represented in the Figure 1 (see in the following sub-section).

At this point, we thought of analyse intricate relationships exist between the motor processes, which may have some extrapolative impacts on the tandem walking ability evident among children assigned to different groups. Thus, multiple linear regression analyses were carried out to conceptualise predictive relationships between motor skill factors in influencing tandem walking ability.

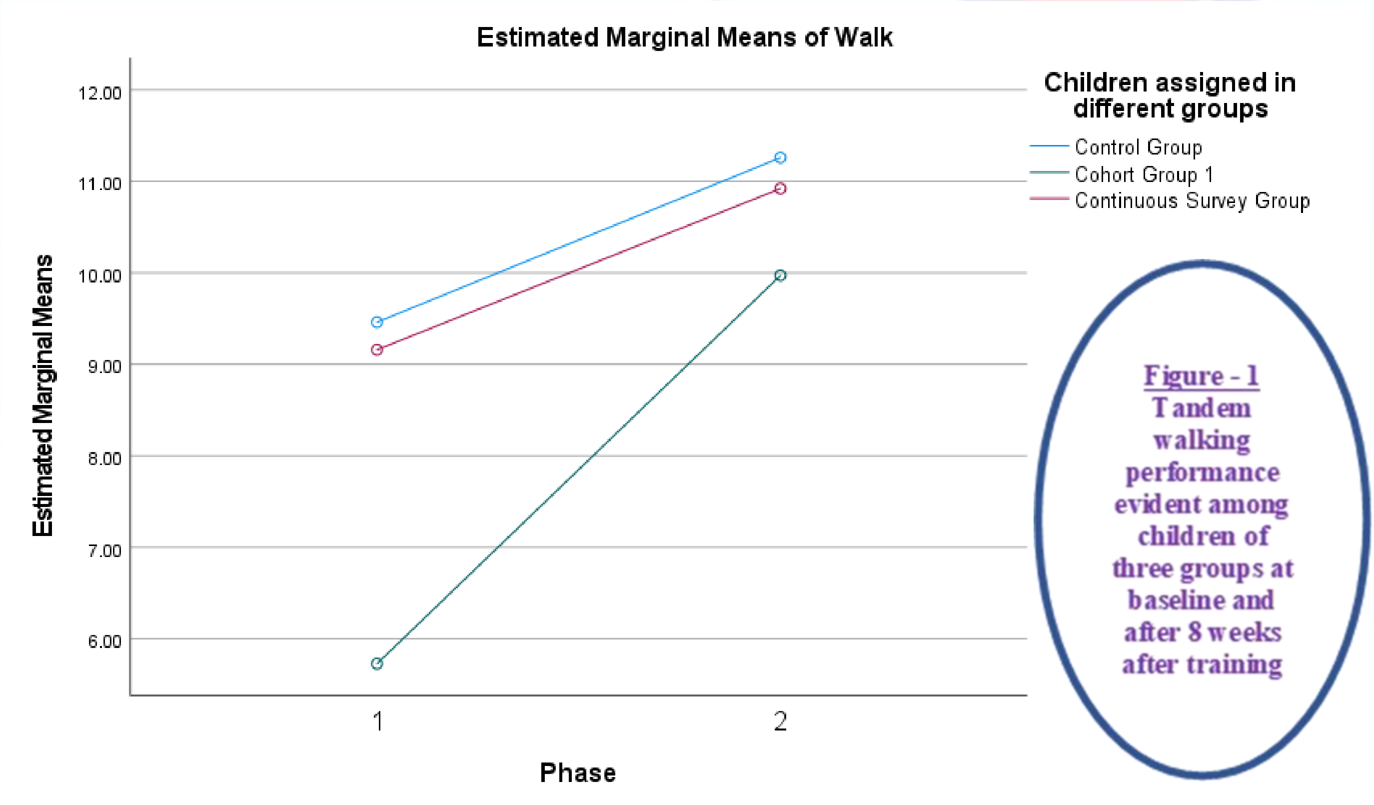

Figure - 1 Tandem walking performance evident among children of three groups at baseline and after 8 weeks after training

Table 3 - Multiple Linear Regression Outcomes – on Tandem Walking Performance evident among children of Control group

Model *a*. Conceived only for the Control group participants DV: At 8th week -Walking -How far was the child able to walk with 1 or 2 feet on the line?	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	4.520	.627		7.215	.000					
Pre-int. Balance - How many seconds was the child able to stand on the right foot?	-.184	.059	-.264	-3.104	.003	-.373	-.324	-.157	.354	2.826
Balance at 8th week - How many seconds was the child able to stand on the left foot?	.664	.110	.330	6.038	.000	.425	.555	.305	.858	1.165
Pre-int. Balance -How many seconds was the child able to stand on their tiptoes?	.171	.091	.158	1.882	.063	-.144	.203	.095	.365	2.741
Pre-int. Walking -How far was the child able to walk with 1 or 2 feet on the line?	.460	.083	.523	5.519	.000	.800	.520	.279	.285	3.513
Pre-int. Walking -Carrying an object how far was the child able to walk?	.256	.085	.319	3.000	.004	.759	.314	.152	.226	4.421
Pre-int. Walking -Walking sidestep how far was the child able to walk?	-.131	.066	-.159	-1.991	.050	.546	-.215	-.101	.403	2.481

[a](F (6, 82) = 51.657, p < 0.000) Model Adj. R^2 = 77.5%.

Multiple linear regression analysis outcomes in this table (conceived for the control group participants), however, revealed that the independent predictors, for instance, pre-intervention level tandem walking skills, precisely tandem walking distance (p = .000), balancing ability (standing on right foot) at the pre-intervention level (p = .003), carrying ability of the children while walking, evident at the pre-intervention phase (p = .004), pre-existing side-step walking ability of the children (p = .050), and balance performance (standing on left foot) evident after 8 weeks (p = .000) together could predict 77.5% of variance in changes in the levels of tandem walking task performed after 8 weeks of training (refer to model ***c***). Thus, it could be clarified that, those independent predictors together had their shared contributions to account for significant amount of unique variance of tandem walking task performed after 8 weeks (77.5% of the unique or exclusive variance, got explained).

Table 4 - Multiple Linear Regression Outcomes – on Tandem Walking Performance evident among children of Cohort 1 group

Model *b*. Conceived only for the Cohort 1 participants DV: At 8th week -Walking -How far was the child able to walk with 1 or 2 feet on the line?	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	8.302	.546		15.211	.000					
Pre-int. Walking -How far was the child able to walk with 1 or 2 feet on the line?	.328	.055	.323	5.943	.000	.362	.359	.320	.981	1.019
Pre-int. Balance - How many seconds was the child able to stand on the right foot?	-.254	.045	-.383	-5.702	.000	-.123	-.346	-.307	.644	1.552
Balance at 8th week - How many seconds was the child able to stand on the right foot?	.418	.055	.509	7.638	.000	.280	.443	.411	.654	1.530

[b]*(F (3, 239) = 35.210, p < 0.000) Model Adj. R2 = 29.8%.*

In this table (conceived for the Cohort 1participants), predictive contributions of balancing and tandem walking ability between Outcome of the multiple linear regression analysis in this table revealed that, independent predictors such as tandem walking skills observed at the pre-intervention level, for instance, tandem walking distance (p = .000), balancing ability (standing on right foot) evident at pre-intervention phase, and balancing ability (standing on right foot) evident after 8 weeks of YA intervention training (p = .000), together could predict 29.8% of variance in changes in the levels of tandem walking task performed after 8 weeks of training (refer to model ***b***). Thus, it could be clarified that, those independent predictors together had their shared contributions to account for significant amount of unique variance of tandem walking task performed after 8 weeks (29.8% of the unique or exclusive variance, got explained).

Table 5 - Multiple Linear Regression Outcomes – on Tandem Walking Performance evident among children of Continuous survey group

Model c. Conceived for Continuous Survey participants only DV: At 8th week -Walking -How far was the child able to walk with 1 or 2 feet on the line?	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	1.768	.718		2.461	.016					
Pre-int. Walking -How many feet was the child able to keep on the line?	1.096	.551	.104	1.987	.050	.558	.212	.085	.669	1.494
Pre-int. Walking -How far was the child able to walk with 1 or 2 feet on the line?	.737	.056	.722	13.067	.000	.879	.819	.560	.601	1.664
Balance at 8th week -How many seconds was the child able to stand on the right foot?	.158	.026	.280	6.110	.000	.546	.555	.262	.875	1.143

[c](F (3, 84) = 153.563, p < 0.000) Model Adj. R^2 = 84%

Outcome of the multiple linear regression analysis in this table (conceived for the Continuous Survey group participants) revealed that, independent predictors such as tandem walking skills observed at the pre-intervention level, for instance, tandem walking distance (p = .000), tandem feet placement (p = .050) and balancing ability (standing on right foot) of the children evident after 8 weeks of YA intervention training (p = .000), together could predict 84% of variance in changes in the levels of tandem walking task performed after 8 weeks of training (refer to model a). Thus, it could be clarified that, those independent predictors together had their shared contributions to account for significant amount of unique variance of tandem walking task performed after 8 weeks (84% of the unique or exclusive variance, got explained).

4. DISCUSSION

Outcomes of descriptive analyses (Table -1) clearly depicted pre-intervention dissimilarity in the central tendency outcomes of tandem walking indices evident among children. Further to that high extents of dispersion in the data were also evident. Findings thus clarified that, without the baseline similarity, impact of YA training cannot be ascertained. As it was expected, ANOVA results (Table - 2) depicted baseline differences in tandem walking ability, which was evident between control and cohort 1, and cohort 1 and continuous survey group as well. This baseline dissimilarity, however, did not continue at the post-intervention phase of analysis, and hence any impact of YA training could not be determined. Graphical representation (Figure - 1) of the outcomes though clarified that at baseline, there was big discrepancy between the data obtained on tandem walking ability evident among the children of three different groups. Figure 1 clarified that, at the phase 1 (i.e., during pre-intervention analysis) children from both control and CS groups were evidentially having similar extent of tandem walking ability, while their counterparts at the C1 had substantially lower level of tandem walking ability. Post-intervention analyses, however, revealed differential extents of improvement in tandem walking performance, which was more obvious for the participants in C1 (i.e., cohort 1). Children from both the control and CS groups were evident to display similar extents of improvement in tandem walking performance, while children from control group did not receive any training at all. But in case of the children of C1, convincing extent of improvement tandem walking was noticed. Since, no baseline similarity was evident, this improvement could not be attributed to the YA training, although in case of C1 participants huge improvement in tandem walking was evident.

These outcomes led us to think on the predictive roles of other sub-components of motor development, such as, balancing, jumping, side-stepping, carrying while walking skills. For that, we conceived three separate models for the three different groups, and hence hereafter, explanations on those are being presented groupwise. Findings from the model ***a***, which was conceived on the children of the control group implied that among the participants, those who were evident as relatively better capable in tandem walking for a longer distance at the pre-intervention level, could understandably perform better at the post-intervention as well, which was carried out after 8 weeks interval. As these children did not receive YA activity training and did not receive any other type of motor skill intervention, the improvement evident in them could be attributed to the pre-existing tandem walking ability evident among these children, which could confirm strongest contribution on the tandem walking task performance evident after 8 weeks (refer to the .523 beta coefficient). Model *a* further explained that every 1% increment in the pre-existing tandem walking ability of the participants would lead to .523% increase in the level of tandem walking task performed after 8 weeks (see Beta Coefficient). Apart from that, the observed part correlation coefficient of this independent variable (IV) (i.e., .279), implied that if the value of part correlation of the IV is squared, the extent of the unique contribution of that IV on the extent of variance changes in the DV (Adj. R^2 value) could be obtained. Hence, removal of that IV will cause 7.7% drop in Adj. R^2 value. Apart from the tandem walking ability some other motor skill factors also were evident to contribute on improvement in walking performance, as this model emerged significant implying the fact that, if the contributory impact of tandem walking ability of the children at the pre-intervention level is regressed or controlled for the extent of the DV, those who had higher pre-existing ability to carry any object while walking, and were evident at post-intervention phase of evaluation, as better capable of balancing using left-foot evidentially also could facilitate in the tandem walking task performance. Furthermore, this model also revealed negative associations between pre-existing level of right-footed balancing ability and side-stepped walking ability and tandem walking task performance, which revealed that among the children, those who had poorer pre-existing right-footed balancing ability and poorer side-stepped walking ability, perhaps were also able to display better tandem walking performance. Predictive outcomes here revealed perplexing relationships, as apart from pre-intervention level higher tandem walking ability, poorer right-footed balancing ability and poorer side-stepped walking ability were evident associated the DV, and contrary to that, higher pre-existing ability to carry medium-sized objects while walking and post-intervention findings of better left-footed balancing ability were also found to contribute on improvement in tandem walking. Outcomes here hinted upon a few possible clarifications, viz., huge dispersion in the tandem walking descriptive data (refer to table 1) were evident, which suggested children of control group might have wide range of differences in their ability to perform tandem walking, and hence differential predictive outcomes were apparent. Besides, compared to their right-footed ability, majority of the children of control group perhaps had better left-lateral balancing ability. Further to that, quite a few of them were capable of carrying any medium-sized object while walking, which implied that they had considerably better bilateral control[18,19], but probably lacked in right-sided ipsilateral control[20], as they by and large evidentially had problems in side-stepped walking.

Here, we intended to look at the outcomes pertaining to the children of the C1 group. Findings from model ***b*** (conceived for the children of the C1 group), however, implied that among the special children assigned to the Cohort 1, at the post-intervention phase, those who were evident as relatively better capable in balancing activity for longer time, could justifiably benefit most from the YA training regimes, and hence that improvement in balancing ability perhaps had strongest contribution on the tandem walking task performance evident after 8 weeks (refer to the .509 beta coefficient). Model *b* further explained that every 1% increment in the balancing ability observed among the children after 8 weeks of training, would lead to .509% increase in the level of tandem walking task performed after 8 weeks (refer to Beta Coefficient). Precisely, those who were better able to perform the right-footed balance, or could learn balancing task better than others, could benefit most. Higher extent of tolerance index observed in colinearity statistics suggested that moderately high extent of (65.4%) variance in balancing ability evident among the children after 8 weeks of YA training, was not predicted by other independent predictors. Apart from that, the observed extent of part correlation coefficient of this IV (i.e., .411), implied that if the value of part correlation of the IV is squared, the extent of the unique contribution of that IV on the extent of variance changes in the DV (Adj. R^2 value) could be obtained. Hence, removal of that IV will cause almost 17% drop in Adj. R^2 value. Basically, it could be assumed that, for the children of C1 group, pre-existing tandem ability and balancing ability together could not ensure improvement in tandem walking skill. Findings of the extrapolative relationships revealed confounding relationships here as well. At the pre-intervention level, children of this C1 were evident as having relatively better ability to perform tandem walking for a longer distance, which justifiably explained the reason behind their improvement in tandem walking. But the observed poorer pre-existing right-footed balancing ability, led us to a confusing situation as alike the children of the control group, perhaps these children (i.e., of C1) also had better left-lateral balancing ability. Findings of model ***b*** suggested a few possible explanations here as well, viz., huge dispersion evident in the tandem walking descriptive data (refer to table 1) indicated wide range of pre-existing difference in the tandem walking ability of the children. This could be further obvious, as at the pre-intervention level, these children had poorest tandem walking ability (Figure 1 clarified this phenomenon as well) and had poorer right-lateral motor (balancing) deficiency as well. Thus, an interesting phenomenon got apparent, as out of the children of C1 group quite a few participants evidentially faced higher extent of troubles pertaining to tandem walking task, while others perhaps did not face the problem up to that critical extent (as the huge dispersion was evident). Here, this problem of poor performance could be theorised as flooring effect[21], who evidentially benefitted most from the YA training and hence, along with others, who already were better able to perform tandem walking, could display marked improvement in tandem walking task.

Model ***c*** (conceived for Continuous Survey or CS group) implied that among the special children participants assigned to the CS Group, at the pre-intervention phase of analysis, those who were evident as relatively better capable in tandem walking for a longer distance, they could understandably benefit most from the YA training regimes, and hence that variable could confirm strongest contribution on the tandem walking task performance evident after 8 weeks (refer to the .722 beta coefficient). Model *a* further explained that every 1% increment in the pre-existing tandem walking ability of the participants would lead to .722% increase in the level of tandem walking task performed after 8 weeks (refer to Beta Coefficient). Precisely, those who had better pre-existing ability, could benefit most. To be precise, those who had better pre-existing ability, could benefit most. Higher extent of tolerance index observed in colinearity statistics suggested that high extent of (60.1%) variance in pre-existing tandem walking ability of the participants was not predicted by other independent predictors. Apart from that, the observed higher extent of part correlation coefficient of this IV (i.e., .560), implied that if the value of part correlation of the IV is squared, the extent of the unique contribution of that IV on the extent of variance changes in the DV (Adj. R^2 value) could be obtained. Hence, removal of that IV will cause more than 31% drop in Adj. R^2 value. Basically, tandem ability and improvement in balancing ability after 8 weeks of training together could not ascertain improvement in tandem walking skill.

In explaining outcomes of the nature of tandem walking performance evident among the children of this group it could be postulated that, perhaps factors identical to those were evident among the children of Control group interplayed in this case as well (as similar characteristic features were noticed in Tables 1 & 2, and in the Figure 1 as well). Here it should be kept in mind that the children from Control group did not get any training, although they displayed higher pre-existing tandem walking ability, which perhaps had major contribution on post-intervention level higher tandem walking score (refer to model ***a***). As per the Model ***a,*** these children were also able to walk carrying medium sized material and had higher extent of left-footed balancing ability. These features hint upon probable pre-existing or dispositional motor developmental advantages, pertaining mostly to the ability to use line of gravity, maintaining stability using the centre of mass, with minimal postural sway[22]. In course of development, by virtue of day-to-day activities, while for the children of control group the ability to maintain postural stability[23] probably helped them to maintain prolong left footed balance[22], ability to use centre of gravity would have helped in carrying materials while walking, and consequently enhanced sensorimotor control[24,25], leading to improvement in tandem walking performance. Although YA training for 8 weeks was introduced, for the children of the CS group the aforementioned hypotheses perhaps fit very well. While control group children had dispositional advantages, those in the CS group had identical tandem walking ability (refer to the Figure 1 and Tables 1 & 2), which perhaps got further facilitated by 8 weeks of motor skills-oriented YA training. But in case of the C1 children, wide range of variability in tandem walking ability perhaps caused major problem, and consequently the C1 group participants collectively had very poor pre-intervention level of tandem walking performance. This poor tandem walking ability evident among majority of the children of C1 group could be interpreted as "flooring effect"[21], in which for everyone the given task appeared absolutely difficult to perform. As it could be postulated, perhaps in tandem walk involving shifting position or walking heel-to-toe, these children faced with problems associated with truncal ataxia[26], or a little extent of impairment in the vestibulospinal activation, might have disturbed the gait stability[27]. These questions are being raised especially as these children were evident to have pre-existing shortcoming in tandem walking, and also in keeping two feet together in one line as well. Once these children got introduced to YA training, those activities which were based on foundation skill, perhaps improved vestibulospinal activation and enhanced spatial orientation and coordinated movement and sense of body-position and self-movement[28], which enabled them to maintain postural stability[23] and sensorimotor control[24]. In case of children of Control condition, as they were already up to a high extent capable of displaying better tandem walking ability, perhaps regularised day-to-day activities led to further regulation over their perceptual world and consequent effective sensorimotor control[28], which at post-intervention phase got further improved. For these children and for their counterparts in the CS group improvement was noticed only up to a little extent. This further improvement for children of both these groups, however, evidentially was not huge, as they probably already reached up to their Ceiling of performance[29,30].

Here we need to acknowledge that, outcomes of this study could be dealt separately by categorising the participants of all the groups into sub-groups of high performing and low-performing participants. Thus, factors affecting both high and low performance could be ascertained, and perhaps a baseline similarity in motor skill outcomes could be obtained. Hence, that pre-intervention similarity would enable us to evaluate the post-intervention level of impacts of YA activity training on motor skills, and on the service delivery areas of inclusion as well.

5. CONCLUSION

Based on the findings following conclusions could be made-

- Baseline analyses revealed dissimilarity in tandem walking performance scores.
- Post-intervention outcomes did not reveal any impact of YA intervention training. Children assigned to the Continuous Survey group could not benefit from the YA training, while their counterparts in the Cohort 1 group were evident to have convincing improvement in tandem walking performance score.
- Outcomes of regression analyses confirmed significance of pre-existing walking and balancing ability evident among the children in predicting efficacy in tandem walking performance after 8 weeks of YA training.
- In order to ascertain efficacy of YA training on tandem walking performance and on other motor skill performances, we recommend future studies on this group of children, categorising them as per baseline performance scores into high performing and low-performing groups of children, which may yield decisive conclusion.

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7. CONTRIBUTION OF AUTHORS

Conceived and designed the experiments: SoS, SrS
Collected data for the experiments: MaA, ArP, FaS
Analysed the data: SoS. SrS
Checked and edited the format of the paper: SoS, SrS
Final approval: SoS, SrS
Wrote the manuscript: SrS, SoS

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DIFFERENTIAL INFLUENCE OF MOTOR SKILLS ON COMPLEX REACTION PERFORMANCE OF RECREATIONAL PLAYERS HAVING COORDINATION DEFICIENCY

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ABSTRACT

Background: Motor and movement coordination problems are prevalent among numerous adolescent and young-adult individuals, which definitely restrain them from participation in competitive sports. Further to that, these limitations reduce their overall mobility, healthy existence and well-being as well.
***Aim*:** This experiment was conducted to investigate on effectiveness of different types of motor coordination techniques, viz., conventional coordination training (CCT); EMG-assisted perceptual motor training (EMG-PMT) and combined introduction of both of the intervention regimes, on simple and complex reaction time performance evident among young-adult recreational athletes.
Method: Forty young-adult male recreational players (18±24 years, $\bar{x}$ = 21.47 and σ = 1.38) identified as having motor and movement coordination problems, were recruited as participants. They were subjected to evaluation of left and right lateral motor control and motor memory; extent of bilateral symmetry in motor and movement coordination; and assessment of both simple and complex reaction task performed under lower and higher difficulty level. Followed by that, participants were categorized into one control and three experimental groups, who were introduced to differential intervention training regimes. Impacts of coordinative training regimes were evaluated during Mid-term, post-intervention, and post-follow-up evaluation sessions.
Results: Mid-intervention analyses revealed improvement in simple reaction performance followed by all of the intervention techniques. Post-intervention analyses, however, revealed that excepting the EMG-PMT intervention, all other intervention techniques were effective in improving simple reaction ability. In case of complex reaction tasks performed under lower difficulty, all the interventions were found effective, while impact of EMG-PMT training was not evident as sustainable. Contrary to that, in case of complex reaction tasks performed under higher difficulty levels, sustainable improvement was noticed both among the participants of the CCT and EMG-PMT groups.
***Conclusions*:** In case of most of the reaction performance evaluations, conventional coordination training and combined introduction techniques were evident as better effective compared to the EMG-assisted perceptual motor training intervention. Multifactorial predictive contributions of motor and movement skill components emerged as facilitative factors for efficient complex reaction performance.

1. INTRODUCTION

Deficiencies in coordination tasks become evidently apparent in almost all the activities[1,2]. Precisely, in gross-motor skills activities characterised by balance, gait[3,4], lateral motor activities[5-7] and reaction ability[8-10], coordination deficiencies may sometimes appear imperceptible. Similarly, activities associated with fine-motor skills deficits, such as, precision tasks[11,12] and dexterity[13] also may not be easily identifiable as well.

In experimental studies on motor learning and control and also in the field of sport psychology one of the most researched aspect is athletic ability to exhibit faster and effective reaction time performances[14-18], which often serve as obvious examples of positive perceptual motor-visual priming in which movement occurs in a set of motor planning process[19]. In serial response time paradigm[20] studies, prominent ideomotor function models are evident, which a few of other researchers[21,22] emphasized as the formation of S-R (i.e., stimulus - response) associations. When participants were engaged in complex (choice) reaction tasks, bulk of the evidence concluded on the patterns of planning involved in selection and initiation of actions, which supported role of ideomotor mechanism (Toner and Moran, 2015). Besides these investigation, few other researchers opined on considering motor visual priming paradigms, as additional direct experimental access to ideomotor cognition and performance, in which real-time (during performance) electrophysiological evaluations could be conducted, and definite patterns of motor action planning involved in coordinative performances could be identified[19].

Implicit procedural memory has already been investigated for long-time by employing reaction-time assessment paradigms[22]. Relationship between procedural memory and reaction time performance got confirmed in another study as well, which reported activation in the motor cortex, in turn facilitated in procedural memory leading to increased arousal and faster reaction time[23]**.** Ideomotor process on the other hand, is more concerned about selection of movements and the cognitive aspects of movements, while the implicit cognitive process in procedural memory, accumulate and utilise information concerning "how to do" a skilled motor action. As a matter of fact, both ideomotor mechanism and procedural memory processes are intricate unconscious mechanisms, and both are evident as associated with reaction time performance, choice-reaction, or complex reaction performance[24]. Cognitive neuroscience investigations although simplified but revealed that the processing of perceptual priming gets regulated by the extra striate cortex, while the conceptual priming is controlled in the left prefrontal cortex[25-27]. In motor learning process, as it is argued, the procedural memory formed often becomes declarative[28,29]. Extensive experimental trials following rigorous methodology, however, emphasized on existence of a dynamic balance between the cortical processes followed in declarative and procedural memory systems[30]. These irregularities evident among existing literatures triggered the thought that perhaps these two unconscious processes may interact in between, and impact of some rigorously designed intervention techniques[31-33] may yield corroborative relationships, explaining pathways to successful coordinative performance.

2. METHODOLOGY

2.1 Participants

Forty Malaysian young-adult male recreational players (18±24 years, $\bar{x} = 21.47$ and $\sigma = 1.38$) were recruited as participants, who were screened following identical selection criteria (inclusion criteria for individuals experiencing coordination deficiencies) and were matched according to extent of coordination disorder (see details at: http://dx.doi.org/10.13140/ RG.2.2.19520.46081).

2.2 Materials Used

In this experiment, for psychomotor evaluations some motor learning and control and coordination related devices were used. Those are 1) Mirror Drawing Test Apparatus (Udyog, India 2013), was used for evaluation of left and right lateral motor control and motor memory (both in clockwise and counter-clockwise direction); 2) Two-Arm-Coordination Tester (Udyog, India 2013), for evaluation of extent of bilateral symmetry in motor and movement coordination; 3) Electronic Reaction Timer (Udyog, India 2009), for evaluation of both simple and complex reaction task performed under lower and higher difficulty level.

2.3 Present Study Procedures

After obtaining the ethical permission from the Research Platform of Universiti Sains Malaysia (Ethical Permission - USM/JEPeM15060226) participants for this experiment were selected based on the pre-scheduled inclusion criteria, and thereafter for the baseline assessments, on pre-scheduled days, they were taken to the laboratory of the exercise and sport science at Univ. Sains Malaysia. This baseline evaluation was carried out group-wise, and for this the participants as well as the assessors were blinded (concealed allocation was done), and hence they were subjected to evaluations of psychomotor parameters, such as, simple muscular reaction ability; complex (choice) reaction ability; motor learning ability (mirror drawing test) and two arm co-ordination test.

At first the participants were subjected to evaluation of visual reaction time by employing the Electronic Reaction Timer (Udyog, India 2009) device, following the standardised protocol[34]. In this activity participants were required to react to specified visual stimulus signals by pressing the respective key of the initiator touchpad (which denotes reaction time - RT) by employing the index finger of their dominant hand. The processor unit assesses the initiation of response (i.e., the RT). Thereafter evaluation of motor control and coordination were carried out following randomised protocols of scheduling. Comprehensive information on assessment procedure pertaining to all these psychomotor tests, viz., reaction performance, motor learning ability and two arm co-ordination test are available in in details at: http://dx.doi.org/10.13140/RG.2.2.19520.46081.

After this baseline analysis, participants were randomly assigned to four different groups (one no-intervention or control group, and three experimental conditions). Employing Research Randomizer Software[35], participants were equally categorized into following four groups – Group A – Control group (n = 10), Group B – Experimental Group I, Conventional Coordination Training (CCT) group (n = 10); Group C – Experimental Group II, Electromyography-Assisted Perceptual Motor Skill training (EMG-PMT) group (n = 10), and Group D – Experimental Group III, Combined introduction of CCT and EMG-PMT intervention technique group (n = 10). Allocation of the participants into different groups was concealed. Qualified therapists were kept blinded, and they were engaged to train participants of the intervention groups, the group-specific intervention techniques, to what they were assigned. All the intervention sessions were monitored and supervised by other sets of experts, who were qualified therapists as well. These experts were also kept blinded.

After assignment into different groups, participants were introduced to intervention sessions, and for that they were supposed to attend the sessions in the laboratory facility of Dept. of Exercise and Sports Science, School of Health Sciences, Univ. Sains Malaysia. Intervention trainings were imparted following an identical protocol (details at: http://dx.doi.org/10.13140/RG.2.2.19520.46081). Details on the intervention regimes are available in the following links. For instance, details on CCT intervention is available at: http://dx.doi.org/10.13140/RG.2.2.11883.46889; those on EMG-PMT intervention at: http://dx.doi.org/10.13140/ RG.2.2.16077.77281, and details on the Combined introduction of CCT and EMG-PMT intervention are available at: http://dx.doi.org/10.13140/ RG.2.2.19223.50086. Participants of experimental groups were imparted therapeutic training sessions in their respective areas of intervention under the supervision of the experimenters, while those who were assigned to control condition, they were not exposed to any of the therapeutic interventions. As per protocol, mid-term assessment was carried out after 8 weeks, (end of 16th session), and post-intervention assessment was conducted after accomplishment of 32nd session. Subsequently, in order to justify the question of sustainability, post-follow-up analysis was also carried out after 12 more weeks of no intervention condition (see details at: http://dx.doi.org/10.13140/ RG.2.2.19520.46081).

3. RESULTS

Descriptive information on the nature of data are provided in the Tables 1 to 3, which contained reports on centralised tendency and normality of the data and the measures of variability, associated with brief information on descriptive analyses. Results of the main study are presented in the Tables 4 to 6, which contained outcomes on Repeated Measure of ANOVA analyses of reaction ability parameters (e.g., Table 4 on Simple reaction performance, and Tables 5 and 6 are on Complex reaction performance scores). Apart from that, multiple linear regression analysis reports are presented in Tables 7 and 8. Here it seems worthy to be mentioned that, in Tables 4 to 6, findings on pairwise comparisons of Simple and Complex Reaction performance parameter scores observed amongst different groups of participants across different phases were presented. Only the most explanatory tables on pairwise comparison, which was observed amongst different groups of participants across different phases were presented. Further to that, Tables 7 and 8 represented outcomes of multiple linear regression analyses, which explained interrelationships between various predictors pertaining to psychomotor parameters and dependent measure of post-intervention outcomes on reaction ability scores obtained by the participants.

Outcomes of this study pertaining to descriptive information on simple reaction ability and complex or choice reaction time task performed under lower and higher difficulty level are presented in the tables 1, 2 and 3. Apart from that, outcomes of the pairwise comparison on simple reaction time performance (refer to table 4) and pairwise comparisons on complex reaction time performance outcomes under both lower (in table 5) and higher difficulty levels (refer to table 6) are also presented. Followed by that, findings of multiple linear regression analyses are detailed in the Tables 7 and 8.

Table 1

Descriptive statistics of Simple Reaction Performance score across the different groups and phases

Phases \ Groups & Statistics	Gr. - 1 - Control group Mean/SD	Gr. - II - Conventional coordination Group Mean/SD	Gr. III - EMG-assisted PMT Group Mean/SD	Gr. IV - Combined Intervention Group Mean/SD
Pre	**32.20/2.04**	**31.20/1.55**	**30.20/2.20**	**31.70/2.00**
Mid	**35.30/3.34**	**28.10/2.64**	**28.10/1.97**	**29.00/2.36**
Post	**33.30/2.36**	**27.70/2.11**	**31.70/2.21**	**29.90/1.66**
Follow up	**35.60/3.17**	**29.00/2.05**	**33.90/1.85**	**32.70/2.50**

Table 2

Descriptive statistics of Complex Reaction Performance with Lower Difficulty level score across the different groups and phases

Phases \ Groups & Statistics	Gr. - 1 - Control group Mean/SD	Gr. - II - Conventional coordination Group Mean/SD	Gr. III - EMG-assisted PMT Group Mean/SD	Gr. IV - Combined Intervention Group Mean/SD
Pre	**54.00/10.36**	**51.80/4.32**	**53.10/7.19**	**52.80/11.21**
Mid	**57.50/7.96**	**44.90/4.20**	**44.10/3.07**	**47.00/7.41**
Post	**59.40/6.52**	**39.80/3.01**	**41.30/4.52**	**45.40/5.08**
Follow up	**63.40/11.64**	**49.10/5.78**	**61.30/12.18**	**49.60/4.06**

Table 3

Descriptive statistics of Complex Reaction Performance with Higher Difficulty level score across the different groups and phases

Phases \ Groups & Statistics	Gr. - 1 - Control group Mean/SD	Gr. - II - Conventional coordination Group Mean/SD	Gr. III - EMG-assisted PMT Group Mean/SD	Gr. IV - Combined Intervention Group Mean/SD
Pre	**62.20/7.51**	**62.20/4.83**	**63.50/10.91**	**62.10/5.00**
Mid	**62.70/11.61**	**50.30/6.00**	**54.40/6.04**	**53.90/10.64**
Post	**64.70/13.92**	**49.20/4.76**	**51.10/3.84**	**52.30/3.97**
Follow up	**62.20/7.51**	**51.80/6.92**	**53.30/3.47**	**56.00/2.71**

Table 4

Pairwise comparisons of Simple Reaction Performance scores observed amongst different groups of participants across different phases

Phases	(I) Different Intervention Group	(J) Different Intervention Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference Lower Bound	Upper Bound
Pre	Control Group	Conventional coordination Group	1.000	.878	1.000	-1.453	3.453
		EMG-assisted PMT Group	2.000	.878	.173	-.453	4.453
		Combined Intervention Group	.500	.878	1.000	-1.953	2.953
	Conventional coordination Group	EMG-assisted PMT Group	1.000	.878	1.000	-1.453	3.453
		Combined Intervention Group	-.500	.878	1.000	-2.953	1.953
	EMG-assisted PMT Group	Combined Intervention Group	-1.500	.878	.578	-3.953	.953
Mid	Control Group	Conventional coordination Group	7.200	1.174	.000**	3.923	10.477
		EMG-assisted PMT Group	7.200	1.174	.000**	3.923	10.477
		Combined Intervention Group	6.300	1.174	.000**	3.023	9.577
	Conventional coordination Group	EMG-assisted PMT Group	.000	1.174	1.000	-3.277	3.277
		Combined Intervention Group	-.900	1.174	1.000	-4.177	2.377
	EMG-assisted PMT Group	Combined Intervention Group	-.900	1.174	1.000	-4.177	2.377
Post	Control Group	Conventional coordination Group	5.600	.940	.000**	2.974	8.226
		EMG-assisted PMT Group	1.600	.940	.585	-1.026	4.226
		Combined Intervention Group	3.400	.940	.005**	.774	6.026
	Conventional coordination Group	EMG-assisted PMT Group	-4.000	.940	.001**	-6.626	-1.374
		Combined Intervention Group	-2.200	.940	.150	-4.826	.426
	EMG-assisted PMT Group	Combined Intervention Group	1.800	.940	.382	-.826	4.426
Follow - Up	Control Group	Conventional coordination Group	6.600	1.094	.000**	3.546	9.654
		EMG-assisted PMT Group	1.700	1.094	.774	-1.354	4.754
		Combined Intervention Group	2.900	1.094	.071	-.154	5.954
	Conventional coordination Group	EMG-assisted PMT Group	-4.900	1.094	.000**	-7.954	-1.846
		Combined Intervention Group	-3.700	1.094	.010*	-6.754	-.646
	EMG-assisted PMT Group	Combined Intervention Group	1.200	1.094	1.000	-1.854	4.254

*p<.05; **p<.001

Table 4 represented outcomes of repeated measure of ANOVA on the level of Simple Reaction Performance scores, which clarified the interaction effect of intervention groups in various phases. Baseline analyses did not reveal any difference across various intervention groups. Mid-term assessment reports, however, revealed compared to the participants of the control group, their counterparts in all of the experimental groups were evident to have faster simple reaction performance. As, no baseline difference was evident, outcomes in the mid-term phase revealed effectiveness of all the interventions in facilitating improvement in simple reaction performance. Post-intervention outcomes on the contrary implied that, excepting EMG-PMT intervention technique, other intervention techniques were evident to facilitate in inducing faster reaction ability. Although the EMG-PMT intervention was not evident as effective, comparative edge was only evident between conventional intervention and EMG-PMT, while combined intervention was not found as better effective. Post-follow-up assessment, however, clarified sustainable improvement in simple reaction ability evident only among participants of conventional coordination group. Thus, outcomes on simple reaction time parameter implied that, excepting the EMG-PMT, other intervention techniques were evident as effective in improving reaction ability, although sustainable effectiveness of conventional co-ordination training was only confirmed. Hence, findings from Table- 4 identified the conventional co-ordination training as convincingly most effective intervention technique.

Table 5

Pairwise comparisons of Complex Reaction Performance with Lower Difficulty scores observed amongst different groups of participants across different phases

Phases	(I) Different Intervention Group	(J) Different Intervention Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Pre	Control Group	Conventional coordination Group	2.200	3.895	1.000	-8.673	13.073
		EMG-assisted PMT Group	.900	3.895	1.000	-9.973	11.773
		Combined Intervention Group	1.200	3.895	1.000	-9.673	12.073
	Conventional coordination Group	EMG-assisted PMT Group	-1.300	3.895	1.000	-12.173	9.573
		Combined Intervention Group	-1.000	3.895	1.000	-11.873	9.873
	EMG-assisted PMT Group	Combined Intervention Group	.300	3.895	1.000	-10.573	11.173
Mid	Control Group	Conventional coordination Group	12.600	2.696	.000**	5.073	20.127
		EMG-assisted PMT Group	13.400	2.696	.000**	5.873	20.927
		Combined Intervention Group	10.500	2.696	.002**	2.973	18.027
	Conventional coordination Group	EMG-assisted PMT Group	.800	2.696	1.000	-6.727	8.327
		Combined Intervention Group	-2.100	2.696	1.000	-9.627	5.427
	EMG-assisted PMT Group	Combined Intervention Group	-2.900	2.696	1.000	-10.427	4.627
Post	Control Group	Conventional coordination Group	19.600	2.212	.000**	13.425	25.775
		EMG-assisted PMT Group	18.100	2.212	.000**	11.925	24.275
		Combined Intervention Group	14.000	2.212	.000**	7.825	20.175
	Conventional coordination Group	EMG-assisted PMT Group	-1.500	2.212	1.000	-7.675	4.675
		Combined Intervention Group	-5.600	2.212	.095	-11.775	.575
	EMG-assisted PMT Group	Combined Intervention Group	-4.100	2.212	.432	-10.275	2.075
Follow - Up	Control Group	Conventional coordination Group	14.300	4.084	.008**	2.898	25.702
		EMG-assisted PMT Group	2.100	4.084	1.000	-9.302	13.502
		Combined Intervention Group	13.800	4.084	.011*	2.398	25.202
	Conventional coordination Group	EMG-assisted PMT Group	-12.200	4.084	.030*	-23.602	-.798
		Combined Intervention Group	-.500	4.084	1.000	-11.902	10.902
	EMG-assisted PMT Group	Combined Intervention Group	11.700	4.084	.042*	.298	23.102

*$p<.05$; **$p<.001$

Table 5 on the other hand depicted outcomes of Complex Reaction Performance task performed under lower difficulty level. Pre-intervention analysis revealed no significant difference across the different groups, while at the mid-term phase all the intervention techniques effectively improved complex reaction task score performed under lower difficulty level. Since the beneficial impacts of the interventions were evident at the post-intervention phases analysis as well, effectiveness of all the interventions got confirmed. Findings of post-follow-up assessment, however, clarified that excepting the EMG-PMT intervention training, all other intervention techniques were evident as effective in facilitating sustainable improvement in complex reaction performance. Thus, the outcomes revealed that all the interventions were found effective in inducing faster complex reaction performance under lower difficult tasks, while conventional as well as combined intervention techniques were evident as convincingly effective training regimes.

Table 6

Pairwise comparisons of Complex Reaction performance with higher difficulty scores observed amongst different groups of participants across different phases

Phases	(I) Different Intervention Group	(J) Different Intervention Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Pre	Control Group	Conventional coordination Group	.000	3.344	1.000	-9.336	9.336
		EMG-assisted PMT Group	-1.300	3.344	1.000	-10.636	8.036
		Combined Intervention Group	.100	3.344	1.000	-9.236	9.436
	Conventional coordination Group	EMG-assisted PMT Group	-1.300	3.344	1.000	-10.636	8.036
		Combined Intervention Group	.100	3.344	1.000	-9.236	9.436
	EMG-assisted PMT Group	Combined Intervention Group	1.400	3.344	1.000	-7.936	10.736
Mid	Control Group	Conventional coordination Group	**12.400**	4.004	**.023***	1.221	23.579
		EMG-assisted PMT Group	8.300	4.004	.272	-2.879	19.479
		Combined Intervention Group	8.800	4.004	.207	-2.379	19.979
	Conventional coordination Group	EMG-assisted PMT Group	-4.100	4.004	1.000	-15.279	7.079
		Combined Intervention Group	-3.600	4.004	1.000	-14.779	7.579
	EMG-assisted PMT Group	Combined Intervention Group	.500	4.004	1.000	-10.679	11.679
Post	Control Group	Conventional coordination Group	**15.500**	3.514	**.001****	5.689	25.311
		EMG-assisted PMT Group	**13.600**	3.514	**.003****	3.789	23.411
		Combined Intervention Group	**12.400**	3.514	**.007****	2.589	22.211
	Conventional coordination Group	EMG-assisted PMT Group	-1.900	3.514	1.000	-11.711	7.911
		Combined Intervention Group	-3.100	3.514	1.000	-12.911	6.711
	EMG-assisted PMT Group	Combined Intervention Group	-1.200	3.514	1.000	-11.011	8.611
Follow - Up	Control Group	Conventional coordination Group	**10.400**	2.487	**.001****	3.456	17.344
		EMG-assisted PMT Group	**8.900**	2.487	**.006****	1.956	15.844
		Combined Intervention Group	6.200	2.487	.104	-.744	13.144
	Conventional coordination Group	EMG-assisted PMT Group	-1.500	2.487	1.000	-8.444	5.444
		Combined Intervention Group	-4.200	2.487	.599	-11.144	2.744
	EMG-assisted PMT Group	Combined Intervention Group	-2.700	2.487	1.000	-9.644	4.244

*$p<.05$; **$p<.001$

Outcomes in the Table 6, alike in case of other parameters revealed no pre-intervention difference observed across various intervention groups in the level of complex reaction task performed with higher difficulty level. At the of mid-term phase, however, only effectiveness of conventional coordination got revealed. Thus, at the mid-intervention level only conventional coordination intervention was found effective in facilitating improvement in complex reaction performance done under higher difficulty level. Post-intervention outcomes although implied that, all the intervention techniques were evident as convincingly effective in improving complex reaction ability. Post-follow-up findings in this parameter revealed that apart from the combined intervention group, improvement in complex reaction ability evidentially sustained among participants of the conventional as well as EMG-PMT intervention groups. Thus, findings confirmed that, excepting the combined intervention technique, other intervention techniques were sustainably effective in improving complex reaction ability, performed under higher difficulty level.

Table 7

Multiple Linear Regression Outcomes – Complex Reaction Performance with Lower Difficulty Level in the Post-intervention phase

Model *a* - Complex Reaction Performance with Lower Difficulty Level	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Intercept)	60.720	7.792		7.792	.000					
Clockwise movement	.136	.052	**.229**	2.603	.014	-.049	.408	.196	.734	1.362
Bilateral Movement	-.003	.002	-.156	-1.942	.060	-.196	-.316	-.146	.879	1.138

*a*F(5, 34) = 28.378, *p* = .000, Adj. R^2 = 77.8%

The model ***a*** (in Table 7) emerged significant as the independent factor such as the extent of clockwise movement performed by the participants in the pre-intervention phase was found to contribute on the dependent measure of complex reaction task performed under lower difficulty level at the post-intervention phase. This model explained that the independent predictor clockwise movement performed by the participants in the pre-intervention phase could explain 77.8% variance of changes in the extent of complex reaction performance.

Table 8

Multiple Linear Regression Outcomes – Complex Reaction Performance with Higher Difficulty Level in the Post-intervention phase

Model *b* - Complex Reaction Performance with Higher Difficulty Level	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Intercept)	47.763	20.097		2.377	.024					
Right lateral motor control	-.548	.171	**-.729**	-3.208	.003	-.108	-.505	-.377	.268	3.734
Clockwise movement	.435	.139	.691	3.131	.004	.041	.496	.368	.284	3.523
Bilateral Movement	.006	.003	.287	1.909	.066	-.013	.329	.224	.611	1.636

*b*F(9, 30) = 4.703, *p* = .001, Adj. R^2 = 46.1%

In Table 8, the model ***b*** emerged significant as the independent factors such as, right lateral motor control and clockwise movement evident in the pre-intervention phase was found to put contributory impacts on the dependent measure of complex reaction task performed under higher difficulty level perceived in the post-intervention phase. These two independent predictors together could explain 46.1% variance of changes in the extent of complex reaction performance.

4. DISCUSSION -

Present experiment intended to examine coordination deficiency as could be revealed through procedural memory process and ideomotor mechanisms. Among individuals experiencing coordination problems, procedural memory process was conceived as associated with a few integral sub-component processes, viz., left, and right lateral movements, bilateral movements, and simple reaction ability performance, while ideomotor mechanism was involved in clockwise and counter clockwise movements, and complex (choice) reaction time performance indices. Experimentation on motor coordination deficiencies, however. rarely approached investigation on aetiological context of procedural memory and ideomotor performance processes. In Addition to that, procedural memory[29,36,37] and ideomotor processes[7,19,38-41] were never empirically investigated following rigorous methodological consideration[5,24,39]. Hence, contributory impacts of both procedural memory and ideomotor process aspects on delayed or deficient motor coordination were not yet substantiated[6,19,29]. Further to that, coordination research paradigms following rigorous methodology, rarely investigated the intervention techniques, whichever was employed in this experiment[7,13,39]. Here, discussion on the outcomes reported, followed probe into contributions of different intervention techniques on aforementioned factors associated with procedural memory and ideomotor performance processes.

Evaluations in all of the phases (i.e., mid-term, post-intervention and post-follow-up) confirmed beneficial impact of conventional coordination training (CCT), in displaying faster simple reaction ability performance (Table 4). The observed improvement in reaction ability, followed by CCT, however, got supported by one of the previous study[31], in which training of coordinated movements reportedly ensued faster simple muscular reaction time. Observed improvement in simple reaction task could be postulated as dynamic and symmetric coordination between cortical processes followed in declarative and procedural memory systems[30]. Findings pertaining to impacts of CCT on factors associated with procedural memory implied that, improvements were evident as sustainable even after 12 weeks of follow-up. This evidence of sustainable improvement convincingly confirmed the effectiveness of CCT in improving procedural memory related aspects associated with deficiency in coordination.

Outcomes associated with investigation on impacts of CCT intervention on factors associated with ideomotor performance process, with particular attention on complex (choice) reaction time performance both with lower (Table 5) and higher (Table 6) difficulty levels were also critically analysed, and the sustainable improvement got supported by previous investigations carried out by Ellemberg and colleagues[31], who advocated on enhanced coordinated movements followed by CCT as vital factor behind faster complex reaction time.

Findings on simple reaction ability performance (Table 4), however, revealed beneficial impact of EMG-assisted perceptual motor training only at the mid-term phase of evaluation, which did not continue until the post-intervention phase of evaluation. Contrary to that, sustainably beneficial impact of CCT intervention was evident, which was found as better effective compared to the EMG-PMT. Present findings of partial effectiveness of EMG-assisted perceptual motor training in improving reaction ability, however did not get any support from previous studies, as no studies considered EMG-PMT intervention following rigorous methodology, and yet we did not come across any study, which carried out so elaborative evaluation, as it was followed in this study. One study was evident to introduce intervention technique, alike that was introduced in EMG-PMT, which compared efficacy of EMG-PMT and conventional coordination training, however, favoured the conventional coordination training over the EMG-assisted perceptual motor training[31].

Comprehensive analysis over these outcomes confirmed that assessment protocols followed for reaction-time could be considered as valid markers of implicit procedural memory evident among healthy and active young-adult individuals[20]. The concept here emphasized on enhanced activation in the motor cortex, which in turn facilitated procedural memory leading to increased arousal and faster RT (Reaction Time). Thus, the lack in improvement evident in simple reaction time performance followed by EMG-PMT, could be attributed to deficient motor activation[23].

Data on the complex (choice) reaction performance performed under lower difficulty level, however, revealed efficacy of EMG-PMT both at the mid-term and post-intervention levels **(Table 5)**. Compared to that, outcomes on complex (choice) reaction performance with higher difficulty level revealed sustainable beneficial impact (refer to Table 6) of the EMG-assisted perceptual motor training. Previous findings from studies on complex reaction performance, conducted in this present laboratory set-up, confirmed similar enhancement in complex reaction performances[17,42,43], although those studies considered EMG biofeedback intervention as intervention regime, while in this study perceptual motor training assisted by EMG indices were introduced to participants. Such an outcome prompted us to postulate that probably participants by-and-large were more skill-dependent[6] and kinematic aspect oriented[44] (concerned and focussed with directional aspects), rather than kinetic-oriented[32].

Present findings of effectiveness of combined training, in improving simple (Table 5) as well as complex reaction ability (Tables 6 and 7), did not get support from any of the previous literatures. This has happened perhaps for the fact that, combined introduction of CCT (which is more commonly introduced therapeutic regime) and EMG-PMT (very rarely employed) were designed for this intervention protocol, which perhaps was never investigated beforehand. Experimental studies in motor learning and control per se and particularly in sport psychology, frequently refer to circumstances wherein positive perceptual motor-visual priming is evident in inducing faster and effective reaction time performances[43]. These studies suggest that positive perceptual priming facilitates movement, through a set of motor planning process[19]. Researchers in this field hinted upon the problems pertaining to complex reaction tasks, which refers to cognitive complexities involved in the task, as there was always chance for the individuals to get exposed to a huge array of stimuli, and to get more engrossed with the quality of stimuli, and not on the motor planning and not on the anticipatory readiness required for successful performance[15]. Bulk of experiments investigated the ideomotor performance, and the patterns of planning involved in selection and initiation of actions of subjects engaged in choice-reaction tasks[45]. It was observed that, instead of emphasizing the formation of R-S (i.e., response - stimulus) associations, participants reportedly paid attention to the S-R (i.e., Stimulus -Response) associations, which perhaps disrupted the serial response time paradigm[20].

Explanations on changes in reaction performance using visual sense modality were attempted by virtue of efficiency in motor-visual coordination, which is based on implicit memory and hence gets processed unconsciously[41]. A recent research from identical experimental set-up on similar population advocated on differential roles of both negative and positive as well as perceptual and conceptual priming, which affect coordinative performances both directly and indirectly[46]. As it was highlighted by the researchers[46], negative priming tends to slow down neural information processing pertaining to movement generation, and with the individualistic dispositional urge to identify semantic resemblance and rational clarity in the stimuli, processing gets further worsened[47] (happens in case of conceptual priming), which remarkably aggravates time-constraints and delimits coordinative performances[9,13,24,48]. Positive[49] as well as perceptual[50] priming, which are based on similarity in form, on the contrary, enable the performers to fasten the processing of ipsilaterally or contralaterally almost identical stimuli, either spontaneously or as fast as possible[5-10,13,24].

While analysing aetiological basis of comparative efficacy evident between the intervention techniques, we faced with major limitations pertaining to scarcity of supportive authentic research literatures. In consequence, verification and justification of the obtained findings and subsequent possibility of generalization of the data became crucially difficult. The simple reaction time task being procedural memory dependent, perhaps was difficult for quite a few of participants, who got perplexed with higher-order procedural memory[51], and hence tried to encode the ‘‘procedures’’ involved in motor task as ‘‘what to do’’[29], instead of the unconscious “how to do” process associated with the skilled motor actions[52].

CCT intervention were mostly characterised by balancing, running, jumping, throwing, catching, dribbling etc. gross motor activities, while the EMG-assisted PMT on the contrary, was designed to put major emphasis on performance-feedback information. We hypothesize that, the disparity in outcomes of CCT and EMG-PMT evident in this experiment, were due to diverse activation in the motor cortex, which facilitated procedural memory differentially and resultant changes in reaction time were evident[45].

At this juncture, we sought for evaluation of the intricate motor and movement coordination dependent factors associated with the complex reaction tasks performed both under lower and higher difficulty levels. Thus, the multiple linear regression analyses were carried out to identify the potential mediators and confounding predictors, which might have unique contributions on dependent outcomes of complex reaction performance. Outcome of the Table 7 clarified unique and direct contribution of clockwise movement on the post-intervention phase score of complex reaction task performed under lower difficulty level, evident among the participants of all of the groups. The model ***a***, however, also depicted that bilateral movement indices were also included in the model, which did not have significant contribution on the extent of changes evident on the complex reaction task. This direct relationship further explained that independent of and excluding the effect of all other predictor variables, lower extent of performance in clockwise movement activity had direct influence on complex reaction score evident among the participants. Higher tolerance index observed in collinearity statistics suggested that high extent of (73.4%) variance in clockwise movement task performed by the participants was not predicted by any other predictor variable. This model further explained that every 1% decrease in clockwise movement task performance score would lead to .229% faster complex reaction ability (refer to

Beta Coefficient of clockwise movement task, having 73.4% of tolerance). Prior to in-depth discussion on regression outcomes, we would like to present outcomes of the model ***b*** (refer to Table 8), which clarified that independent predictors such as, the right lateral motor control and clockwise movement together contributed on the post-intervention performance of complex reaction task performed under higher difficulty level. Here, it should be noted that the right lateral motor control was the main predictor, which irrespective of contribution from any other independent factors, had unique contribution on complex reaction time score. The model ***b*** further explained that every 1% increment in right-handed lateral motor control would lead to .729% faster complex reaction ability (refer to Beta Coefficient of right lateral motor control, having 73.4% of tolerance).

Here outcomes of these two models presented different characteristic relationships, which clarified roles of both procedural memory process and ideomotor mechanism as well. Dependent measure of changes in complex (choice) reaction time performance, which is associated with ideomotor mechanism, got predicted by independent factors associated with both ideomotor function and procedural memory process. In model ***a*** pre-intervention level of clockwise movement (which is an ideomotor function) was found directly associated with post-intervention level of complex reaction time performance (ideomotor mechanism as well). Here, to simplify it could be explained that during the pre-intervention analysis those who had poorer clockwise performance, at the post-intervention phase they were evident to display faster complex reaction ability (when difficulty level was lower). Thus, at lower difficulty level, perhaps the participants could utilise their positive and perceptual motor-visual priming to display faster reaction ability. This improvement in motor-visual priming could be attributed to the intervention techniques introduced to the participants of experimental groups. The model ***b*** on the contrary, depicted a different scenario, in which higher extent of right-handed lateral motor control, evident among the participants at the pre-intervention phase was found to contribute to faster complex reaction performance observed at the post-intervention phase. Thus, a procedural memory-driven factor, i.e., right-handed lateral motor control was evident to improve complex reaction performance, associated with ideomotor mechanism. Here although a secondary role of poorer ability of the participants at the pre-intervention phase to perform clockwise motor task (ideomotor mechanism) was also evident, which might have some additive impacts on the complex reaction task. Precisely the outcomes of model ***b*** implied that those who had higher extent of procedural memory, they had better sense of "how to do" of the right-handed lateral motor task, and were better capable of ipsilateral and contralateral control initiated by right-handed movement, and hence for their enhanced implicit memory, they could utilise their perceptual-positive motor-visual priming required to search the specific stimuli required to respond immediately, and could perform faster complex reaction task as well. Quite a few of the previous studies carried out on similar experimental conditions on simple and complex reaction performance revealed differential predictive relationships as well, which however, mostly hinted up on exclusive autonomic influence[34,53]; emotionality and psychobiological influence[54,55]; mood, emotionality, and psychobiology predictors[18]. Only two of the previous studies attempted to explain peak reaction performance based on perceptual-motor competence, perceptual discrimination ability and better symmetry in bilateral movement coordination[15,56].

This phenomena of interlinked relationships between and contribution of procedural memory-driven performance on the perceptual motor visual priming could be explained on the basis of psychoneurobiological process of "adaptive navigation", which coordinate between several neural circuits stemming from various brain areas to respond to any unknown stimuli or situations[57]. These researchers and other colleagues in the same area hinted upon the facilitative contribution of neuromodulators, especially the role of dopamine in enhancing procedural memory, which allows for parallel processing in several neural structures, all at the same time. As it was hypothesized by contemporary researchers, dopamine pathways expedite neural and cognitive flexibility required for faster adoption to changed situations, and the mesocorticolimbic dopamine pathway enhances psychobiological conditioning to excel in reaction performance[58]. Even though based on regression outcomes, we attempted to explain the aetiological aspects pertaining improvement in reaction performance, the independent predictors were the outcomes of pre-intervention phase of analyses, while post-intervention changes of those parameters, and impacts of those onto reaction performance, could not be evaluated. Further to that, both of the models were conceived, including all of the participants, while some of them also belonged to no-intervention or control group, and others were also assigned to different types of intervention regimes. Thus, outcomes of any particular intervention or when no intervention was introduced, and relative impacts of the coordinative process onto reaction performance, could not be ascertained. These limitations prompted us to recommend needs for future studies considering identical experimental design, following rigorous methodology, and introducing identical intervention protocols to arrive at any decisive conclusion on generalisability of the outcomes of this study.

5. CONCLUSION

In conclusion, it was evident that intervention techniques employed in this study effectively induced faster simple reaction performance. Similarly, in the case of complex reaction tasks performed under lower difficulty levels, sustainable improvement in the complex reaction was noticed among CCT and combined intervention group, while EMG-PMT training effects were not evident as sustainable. Complex reaction tasks performed under a higher difficulty level all the intervention techniques appeared effective in inducing faster reaction performance. Participants of CCT and EMG-PMT intervention groups had sustainable improvement.

Extrapolative relationships revealed that accuracy in clockwise movement ability evident among the participants emerged as a valid influencing factor behind efficient complex reaction performance. As in the case of complex reactions performed under lower difficulty level, accuracy in clockwise movement emerged as the main factor predicting faster reaction performance, complex reactions performed under higher difficulty level, however, was influenced mainly by delayed right-hand lateral motor control, while accuracy in clockwise movement along with faster bilateral movement ability served as additive factors, which contributed behind the faster complex reaction performance. Precisely, the more difficulty involved in the complex reaction task required higher-order motor visual priming, hence the right-handed participants comparatively had to avail more time for successful complex reaction performance. To substantiate the outcome of this study, we recommend more replicated studies on this paradigm.

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7. CONTRIBUTION OF AUTHORS

Conceived and designed the experiments: SoS, , HaH, FoH,
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Evaluation of Quality of Literatures: SrS, SoS
Analysed the data: SoS
Wrote the manuscript: SrS, SoS
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DIVERSE PREDICTIVE INFLUENCE OF MOOD FACTORS ON VMBR AND BIOFEEDBACK INTERVENTIONS ENHANCING THIRTY-METER DASH PERFORMANCE

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Mood, VMBR, Biofeedback, Agility, Predictive influence, Athletics, Performance, Sport skill

ABSTRACT

Background: Success in athletic performance is recognised as resultant of accurate-most effective reproduction of acquired skills into performance excellence. To ensure this, athletes try to embrace various authentic therapeutic techniques. These intervention regimes, being mediated by diverse emotional and cognitive-motivational processes enable the athletes excel in their performance.
***Aim*:** This experiment was conducted to examine efficacy of visuo-motor behaviour rehearsal (VMBR), and composite biofeedback intervention regimes, on mood states, in modulating transient emotional aspects inhibiting performance of athletic skills.
Method: Promising athletes of Malaysian national Sports Council (n = 39) experiencing crises concerning performance deficiencies were recruited as participants. They were subjected to assessment of mood states, substantiated with simultaneous evaluation of autonomic measures of arousal and thirty-meter-dash performance. Followed by that, athletes were exposed to VMBR and biofeedback training regimes. Impacts of psychotherapeutic training regimes were evaluated during Mid-term, post-intervention, and post-follow-up evaluation sessions.
Results: Mid-intervention analyses revealed facilitative impact of only biofeedback intervention, while both post-intervention and post-follow-up evaluations confirmed that both the intervention regimes improved thirty-meter-dash performance among athletes. No such improvement as such was evident among athletes of the control condition. Besides all these, the multiple linear regression analyses outcomes revealed differential predictive associations between mood factors and thirty-meter-dash performance outcomes, evident among athletes of different experimental conditions.
***Conclusions*:** Post-intervention analyses revealed facilitative impacts of both the intervention regimes in improving thirty-meter-dash performance among athletes. At pre-intervention phase, athletes of VMBR group were evident to perceive lesser extent confusion, while at post-intervention phase, lesser perceived anger was evident to predict faster thirty-meter-dash. Biofeedback trainees on the other hand, perceived lesser extent of fatigue at the pre-intervention phase, which predicted faster dash performance. But the post-intervention evaluation revealed athletes of biofeedback condition had higher extent of depression and lower extent of confusion, which eventually got regulated by virtue of biofeedback training, and hence those athletes could display faster dash performance.

1. INTRODUCTION

Committed athletes always dedicate themselves for exceptional athletic achievements. This performance excellence essentially may occur, if in competitive situations athletes can effectively maintain skilful performance accuracy. In course of their actions, elite athletes often become susceptible to face with the traumatic situations, and hence they always need adequate coping skills to regulate themselves under stressful competitive situations[1-5]. Apart from the prevalent myth concerning coping as a natural ability of the elite athletes[1,2&6], often players and athletes themselves are evident to carry self-deceptive notion concerning hardy personality[7,9,10,] and mental toughness[7- 11].

Aetiology of performance disaster in athletic skills, particularly pertaining to power, speed and agility aspects have so far been discussed mostly based on physical composition[12], somatotype[13], kinanthropometric[14,15] features, muscle-strength[16,17], stride length[17,18] and force[18] and neuromuscular conditioning[19] cognitive dissonance associated with motor and movement skill and coordination[20,21], debilitating impacts of heightened arousal and anxiety, arousal, and narrowing of attention, anxious apprehension etc. concerning athletic performance[21].

Apart from that, numerous researchers dealt with factors associated with mood[22,23] and emotionality[24-26] behind athletic performance disaster[27,28], which were conducted employing subjective self-report indices only. If these aspects are not objectively corroborated, those are susceptible to contain ‘response biases’[29]. Some of those also may be restricted to ‘Socially Desirable Responding’[30]; ‘Acquiescent Responding’ and ‘Extreme Responding’[31]. In some cases, those were also evident as having less valid, weakened and source of fallible data[32]. Here, bulk of investigations conducted on identical population, appeared to resolve these issues by pertinently substantiating the self-report data[33-35] with real-time direct psychobiological evaluation[34,35] (ERP or habituation paradigm estimation of emotional indices) and provided objective aetiological evidence[33-35].

Once the causative factors are accurately identified, studies dealt with performance disaster can formulate more pinpointed intervention plans. In search for relevant intervention regimes following authentic protocols, we carried out extensive literature search on RCTs implemented psychological skill training techniques in the field of athletics and observed that, quite a few studies[36-45] incorporated visuomotor behaviour rehearsal (VMBR) clearly confirmed beneficial impacts of either VMBR or visualization or imagery training, while one study[46] partially confirmed improvement in athletic skills. Similarly, out of numerous RCTs carried out on impacts of biofeedback and neurofeedback, quite a few studies[4,5,21,33-35] clearly confirmed beneficial impacts of either biofeedback[33-35,47-51,53,54] or neurofeedback[49,52,55] training on improved sport performance[47,48,50,57-59].

In case of both of the types of intervention techniques employed, however, extent of heterogeneity was observed as high. This limitation raised questions on the methodological clarity of the RCTs conducted, and hence to provide answers to this question, we earnestly felt a need to carry out more authentic investigation following rigorous methodology, on impacts of both VMBR and biofeedback on specific athletic skill. Further to that, we intended to examine the mediating and/or moderating roles of emotionality and mood states in predicting pathways to modify goal-oriented behaviour towards successful achievement and persistent use of athletic skills. Given that the intervention techniques may facilitate in excelling in athletic skills, comprehensive analysis of intricate processes, through which interventions enable the athletes, and probable roles of mood factors, if any, in facilitating or hindering these process would be intriguing to ensure suitable utilization of interventions for athletic achievements.

2. METHODOLOGY

Thirty-nine young male Malaysian promising athletes aged between19 to 22 years ($\bar{x}$ = 20.68 and σ = 1.642) were recruited as participants of this experiment. They were identified primarily by their coaches as passing through performance disaster, owing to their perceived helplessness and apprehensions concerning performance catastrophe.

2.1 Inclusion Criteria

I. Promising athletes trained in National Council of Sports (MSN) Terengganu & Kelantan.
II. Resting HR lower than 56 BPM & VO2 max (51.5 – 58.4 mL/(kg.min)).
III. No pre-existing medical as well as psychopathological complication.
IV. No previous exposure to biofeedback and visuomotor behaviour rehearsal (VMBR) training program.
V. Athletes who could adapt to the intervention training regimes within 3 sessions.

2.2 Exclusion Criteria

I. Athletes who could not learn the intervention within three sessions.
II. Participants who were not present for at least 85% to 90% of therapeutic sessions.
III. Athletes who did not attend interventions for three consecutive sessions.
IV. Any incidence of major illness during training period and follow-up session.
V. Any occurrence of injury during training period and follow-up session.
VI. Participants with significant change in their lifestyle which can influence their mental status and can increase their stress level which in turn may hinders their performance.

2.3 Materials Used

I. Brunel Mood Scale - BRUMS[60]
II. Psychobiological recorders: Skin conductance - Sc (ProComp5 Infinity, USA, 2014).
III. Electrical Muscle Potentiality (Mega ME6000 SEMG Apparatus, USA, 2008).
IV. Heart Rate Monitor (Polar HR Monitoring System – Polar Team System).
Materials for evaluation of Speed (30-Meter-Dash).

2.4 Group Randomization

Research Randomizer Software[61] was employed to categorize athletes equally into following three groups – 1) Group A – Control group (n = 13); 2) Group B – Experimental Group I, VMBR training group (n = 13); 3) and Group C – Experimental Group II, composite biofeedback intervention group (n = 13). Allocation of the participants into different groups was concealed, and all the intervention sessions were supervised by qualified therapist.

2.5 Present Study Procedures

Ethical approval for this study was obtained from the Research Platform of Universiti Sains Malaysia (Ethical Permission - USM/JEPeM15060224**)**. One of the experimenters herself being a qualified trainer of athletics, got herself attached with the National Sport Council of Kelantan and Terengganu provinces of Malaysia, and hence she along with her fellow coaches could identify the athletes having major crises.

Athletes in this experiment were evaluated for four times, viz., pre-mid and post-intervention analyses and post-follow-up analysis as well, and in every phase of analysis, they were subjected to evaluations of mood states employing the BRUMS[60]; which was corroborated with simultaneous assessment of phasic Sc indices following standardised protocols[1,2,4,5,33,35,56]. Habituation paradigm changes in Sc indicators following the self-report indices were recorded. Followed by this assessment of basic athletic skills, viz., speed, endurance etc. were conducted. Thirty-Meter-Dash was evaluated following the most valid and reliable test protocol was followed[62,63], which ensures evaluation of athletic ability to build up acceleration from static position to achievement of maximum speed[64]. Assessment of 30-meter dash was conducted for three times and out of the three chances, for this study the best acceleration was considered as the data.

Athletes assigned to experimental conditions were introduced to intervention sessions, in the laboratory facility of Dept. of Exercise and Sports Science, School of Health Sciences, Univ. Sains Malaysia. Psychotherapeutic interventions, i.e. VMBR and biofeedback training intervention were imparted following an identical protocol (15 min.s/day, 2 days/week for 10 weeks) (details available at: http://dx.doi.org/10.13140/RG.2.2.21756.05767). Athletes of Gr. B and Gr. C were imparted therapeutic training sessions in their respective areas of intervention under the supervision of the experimenters. For the initial 10 weeks, training sessions were scheduled for 15 minutes, while as the training intensity progressed for the next 10 weeks, sessions continued for 20 minutes per day. Athletes of no-intervention or control group were not exposed to any of the therapeutic interventions. As per protocol, mid-term assessment was carried out after 5 weeks, (end of 10th session), and post-intervention assessment was conducted after accomplishment of 20th session. Subsequently, in order to justify the question of sustainability, post-follow-up analysis was also carried out after 10 more weeks of no intervention condition.

3. RESULTS

Basic information on the nature of data are provided in the Table 1, which contained reports on centralised tendency and normality of the data and the measures of variability, related to brief information on descriptive analyses. Thereafter the results of the main study are presented, in which the reports on Repeated Measure of ANOVA were detailed (Refer to Table 2).

Table 2 represented pairwise comparisons of Thirty-Meter Dash parameter score observed amongst different groups of participants across different phases. Only the most explanatory table on pairwise comparison, which was observed amongst different groups of athletes across different phases was presented.

Tables 3, 4 and 5 represented outcomes of multiple linear regression analyses, which explained interrelationships between various mood state predictors and dependent measure of thirty-meter-dash score obtained by the athletes at the post-intervention phase of analysis.

Table 1- *Descriptive Statistics on 30-meter dash performance score*

Phases	Intervention Groups	Mean	SD	N
Pre-Intervention Scores	Control	4.5785	.19566	13
	VMBR Trainees	4.3483	.26620	13
	Biofeedback Trainees	4.3395	.24119	13
Mid-Term-Intervention Scores	Control	4.1847	.12382	13
	VMBR Trainees	4.0325	.23244	13
	Biofeedback Trainees	3.9223	.11570	13
Post-Intervention Scores	Control	4.0193	.09537	13
	VMBR Trainees	3.8058	.22648	13
	Biofeedback Trainees	3.7023	.06002	13
Post-Follow-Up Phase Scores -	Control	4.211	.1925	13
	VMBR Trainees	3.956	.1224	13
	Biofeedback Trainees	3.934	.1353	13

Table 2

Pairwise Comparisons of 30-meter dash parameter scores observed amongst different groups of participants across different phases

Measurement Sessions		**Groups**	**Mean Difference**	**SE**	**P Value**	**95% Confidence Interval Lower Bound**	**95% Confidence Interval Upper Bound**
Pre-intervention Phase	Control	VMBR Trainees	.230	.099	.145	-.042	.503
		Biofeedback Trainees	.239	.099	.118	-.033	.511
	VMBR Trainees	Control	-.230	.099	.145	-.503	.042
		Biofeedback Trainees	.009	.099	1.000	-.264	.281
	Biofeedback Trainees	Control	-.239	.099	.118	-.511	.033
		VMBR Trainees	-.009	.099	1.000	-.281	.264
Mid-intervention Phase	Control	VMBR Trainees	.152	.069	.189	-.037	.341
		Biofeedback Trainees	.262*	.069	.002	.073	.451
	VMBR Trainees	Control	-.152	.069	.189	-.341	.037
		Biofeedback Trainees	.110	.069	.691	-.079	.299
	Biofeedback Trainees	Control	-.262*	.069	.002	-.451	-.073
		VMBR Trainees	-.110	.069	.691	-.299	.079
Post-intervention Phase	Control	VMBR Trainees	.214*	.051	.001	.074	.353
		Biofeedback Trainees	.317*	.051	.000	.178	.456
	VMBR Trainees	Control	-.214*	.051	.001	-.353	-.074
		Biofeedback Trainees	.104	.051	.276	-.036	.243
	Biofeedback Trainees	Control	-.317*	.051	.000	-.456	-.178
		VMBR Trainees	-.104	.051	.276	-.243	.036
Post-Follow-up Phase	Control	VMBR Trainees	.255*	.056	.000	.102	.409
		Biofeedback Trainees	.277*	.056	.000	.124	.430
	VMBR Trainees	Control	-.255*	.056	.000	-.409	-.102
		Biofeedback Trainees	.022	.056	1.000	-.132	.175
	Biofeedback Trainees	Control	-.277*	.056	.000	-.430	-.124
		VMBR Trainees	-.022	.056	1.000	-.175	.132

Outcomes of Pairwise comparison of the data on Thirty Mt. Dash performance score are reported in the Table 2, and the post hoc pairwise comparison using the Bonferroni correction revealed that at the mid-term intervention phase of assessment, significant difference was evident only between the control group and the biofeedback intervention training group ($p < 0.002$). At the post-intervention phase of evaluation, however, significant differences were evident between the control and both the intervention groups. Reports revealed significant differences between the control and VMBR ($p < 0.001$) and biofeedback intervention ($p < 0.000$). Finally, the post-follow-up evaluation also revealed similar scenario, since differences in Thirty Mt. Dash performance scores were evident between control and the VMBR intervention training group ($p < 0.000$), as well as between control and biofeedback training group ($p < 0.000$).

Table 3A

Model a1 - Summary of multiple linear regression analysis, explaining changes in Thirty-M-Dash scores as predicted by the measures of mood states observed at the pre-intervention phase of analyses amongst the athletes in Control condition

Model *a1:* Dep. Variable - Pre-Intervention Thirty-M-Dash Scores	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Intercept)	8.161	1.066		7.654	.000					
Tension	-.091	.026	-1.708	-3.494	.008	-.343	-.777	-.748	.192	5.213
Depression	.093	.033	1.756	2.845	.022	-.195	.709	.609	.120	8.307
Vigour	-.045	.013	-1.534	-3.349	.010	-.246	-.764	-.717	.219	4.574

a1{F (3, 9) = 4.159, P < 0.049), Adj. R^2 = 45.0%}.

In Table 3A, the model ***a1*** emerged significant as the pre-intervention level of mood states, viz., Tension, Depression and Vigour together could explain 45% variance of changes in the extent of pre-intervention level of Thirty-M-Dash performance scores. Model ***a1*** explained direct relationship between Depression score and the extent of Thirty-M-Dash performance observed in the athletes. Further to that, Tension and Vigour were also evident to have inhibitive influences on the extent of pre-intervention level of Thirty-M-Dash performance.

Table 3B

Model a2 - Summary of multiple linear regression analysis, explaining changes in Thirty-M-Dash scores as predicted by the measures of mood states observed at the post-intervention phase of analyses amongst the athletes in Control condition

Model *a2*: Dep. Variable - Post-Intervention Thirty-M-Dash Scores	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Intercept)	3.351	.258		12.996	.000					
Depression	-.014	.007	-.556	-2.201	.055	.162	-.591	-.414	.554	1.806
Vigour	.008	.003	.574	2.665	.026	.365	.664	.501	.762	1.312
Fatigue	.018	.005	.897	3.934	.003	.626	.795	.740	.680	1.470

[a2]{F (3, 9) = 6.414, P < 0.013), Adj. R^2 = 57.5%}.

In Table 3B, the model ***a2*** emerged significant as the pre-intervention level of mood states, viz., Depression, Vigour and Fatigue together could explain 57.5% variance of changes in the extent of post-intervention outcome of Thirty-M-Dash performance scores. Model ***a2*** explained the inverse relationship between Depression score and the extent of Thirty-M-Dash performance observed in the athletes. Further to that, Vigour and Fatigue were also evident to have direct influence on the extent of Thirty-M-Dash performance.

Table 4A

Model b1 - Summary of multiple linear regression analysis, explaining changes in Thirty-M-Dash scores as predicted by the measures of mood states observed at the pre-intervention phase of analyses amongst the VMBR trainee athletes

Model *b1*: Dep. Variable - Pre-Intervention Thirty-M-Dash Scores	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Intercept)	3.470	.309		11.222	.000					
Confusion	.016	.006	.657	2.890	.015	.657	.657	.657	1.000	1.000

[b1]{F (1, 11) = 8.352, P < 0.009), Adj. R^2 = 38.0%}.

Model ***b1*** in the Table 4A on the other hand depicted that, only one measure of mood states, viz., Confusion evaluated in the pre-intervention phase, was observed to predict changes in the dependent measure of Thirty-M-Dash performance scores. This model (model ***b1***), however, could explain 38% variance of change in the extent of Thirty-M-Dash performance scores evident at the pre-intervention phase of evaluation. Model ***b1*** explained direct contribution of anger observed among athletes of VMBR group on their Thirty-M-Dash performance score evident at the pre-intervention phase of evaluation.

Table 4B

Model b2 - Summary of multiple linear regression analysis, explaining changes in Thirty-M-Dash scores as predicted by the measures of mood states observed at the post-intervention phase of analyses amongst the VMBR trainee athletes

Model *b2*: Dep. Variable - Post-Intervention Thirty-M-Dash Scores	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Intercept)	1.133	.840		1.350	.204					
Anger	.056	.018	.693	3.189	.009	.693	.693	.693	1.000	1.000

[b2]{F (1, 11) = 10.168, P < 0.009), Adj. R^2 = 43.3%}.

Model ***b2*** in the Table 4B on the other hand depicted that, only one measure of mood states, viz., Anger evaluated in the pre-intervention phase, was observed to predict changes in the dependent measure of Thirty-M-Dash performance scores. This model (model ***b2***), however, could explain 43.3% variance of change in the extent of Thirty-M-Dash performance scores evident at the post-intervention phase of evaluation. Model ***b2*** explained direct contribution of anger observed among athletes of VMBR group on their Thirty-M-Dash performance score evident at the post-intervention phase of evaluation.

Table 5A

Model c1 - Summary of multiple linear regression analysis, explaining changes in Thirty-M-Dash scores as predicted by the measures of mood states observed at the pre-intervention phase of analyses amongst the Biofeedback trainee athletes

Model *c1*: Dep. Variable - Pre-Intervention Thirty-M-Dash Scores	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Intercept)	2.905	.665		4.367	.001					
Fatigue	.028	.013	.546	2.164	.053	.546	.546	.546	1.000	1.000

[c1]{F (1, 11) = 4.863, P < 0.048), Adj. R^2 = 23.5%}

In Table 5A, the model ***c1*** was conceived for the athletes of biofeedback intervention group. This model emerged significant as the mood state such as, Fatigue evaluated in the pre-intervention phase, could explain 23.5% variance of changes in the extent of pre-intervention level of Thirty-M-Dash performance scores. Model ***c1*** explained the direct relationship between feeling of fatigue and the extent of Thirty-M-Dash performance observed in the athletes at the pre-intervention phase of evaluation.

Table 5B

Model c2 - Summary of multiple linear regression analysis, explaining changes in Thirty-M-Dash scores as predicted by the measures of mood states observed at the post-intervention phase of analyses amongst the Biofeedback trainee athletes

Model *c2:* Dep. Variable - Post-Intervention Thirty-M-Dash Scores	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Intercept)	4.025	.162		24.832	.000					
Depression	-.011	.003	-.708	-3.248	.009	-.523	-.716	-.671	.897	1.115
Confusion	.004	.002	.579	2.653	.024	.351	.643	.548	.897	1.115

^{c2}{F (2, 10) = 6.719, P < 0.014), Adj. R^2 = 48.8%}.

In Table 5B, the model ***c2*** was conceived for the athletes of biofeedback intervention group. This model emerged significant as the mood states such as, Depression and Confusion evaluated in the pre-intervention phase, together could explain 48.8 % variance of changes in the extent of post-intervention level of outcome of Thirty-M-Dash performance scores. Model ***c2*** explained the inverse relationship between depression score and the extent of Thirty-M-Dash performance observed in the athletes. Apart from that, direct relationship between confusion and extent of Thirty-M-Dash performance score was also evident.

4. DISCUSSION

Results in Table 2 represented the scenario of the repeated measure of ANOVA outcomes, which clarified that during the mid-term analysis, only biofeedback intervention technique was evident as effective in inducing faster thirty-meter-dash performance observed among the athletes. Postintervention analysis, however, revealed facilitative impacts of both VMBR and biofeedback intervention techniques in inducing faster thirty-meter-dash performance, which were reported to continue even at the post-follow-up phase of evaluation.

This sustainably beneficial impact of VMBR intervention regime on the Thirty Mt. Dash performance, got evidentially supported by several previous research investigations[45,58,65-67]. As Silmani and the coresearchers[67] conducting an extensive systematic review on impacts of differential types of visualization techniques earlier pointed out and confirmed positive role of visualization on increment in Thirty Mt. Dash performance[45,65,66]. Here we need to clarify that Hammoudi-Nassib and colleagues[65] conducted their experiment on sprint performance, while in this study thirty-Mt. Dash performance was investigated, which confirmed sustainable impact of VMBR intervention. Apart from that, the psyching-up strategies employed by Hammoudi-Nassib and coresearchers[65], was also different from what was used in this study, as in this study action-oriented VMBR training was imparted. Nonetheless, findings of this study, received confirmatory support from the previous studies[58,66,67].

Similarly, high extent of sustainably facilitative impact of Biofeedback Intervention training on Thirty Mt. Dash performance also got endorsed by quite a few of previous findings[2,11,43,44,46,68]. Researchers working on sprint-like agile performances, aligned present outcome on Thirty Mt. Dash performance, and confirmed that biofeedback intervention improves ipsilateral as well as contralateral coordination of limb joints, required to produce faster Thirty Mt. Dash performance[69]. Improvements evident in this performance could be attributed to the symmetrical enhancement in muscular contractibility in the rectus femoris muscles of the players, which however could definitely be attributed to the biofeedback training[50,70].

Once the facilitative impacts of both interventions got confirmed, to interpret the intricate processes mediated the improvements, we investigated on the predictive roles of mood aspects and emotional make-ups of the athletes, who received intervention training. Outcomes from the Table 3A (model ***a1***) clarified unique contribution of mood factor depression on the pre- intervention level of thirty-meter-dash performance score, evident among the athletes of the control group. This direct relationship independent of and excluding the effect of all other predictor variables further explained that lower extent of depression had direct influence on faster thirty-meter-dash performance score evident among these athletes. The model ***a1*** explained that every 1% decrease in depression perceived by the athletes would lead to 1.756% faster thirty-meter-dash performance (refer to Beta Coefficient of depression). Apart from this, the model also depicted direct predictive contribution of tension and vigour on the pre-intervention level of thirty-meter-dash performance score. These relationships, however, clarified that higher extent of tension as well as vigour were associated to faster thirty-meter-dash performance score evident at pre-intervention phase of assessment. Relationships between mood factors and pre-intervention level of thirty-meter-dash performance evident among the athletes of the control condition clarified that, faster performance of thirty-meter-dash was evident among the athletes who perceived lesser extent of depression but had relatively heightened feelings of both tension and vigour. Here depression emerged as the most important predictor for thirty-meter-dash performance, which implied that, if athletes feel lesser extent of depression, irrespective of their level of tension and feelings of vigour, they can display faster thirty-meter-dash performance.

Outcomes from the Table 3B (based on model ***a2***) on the other hand, clarified unique contribution of feeling of fatigue on the thirty-meter-dash performance score evident at the post-intervention evaluation, among the athletes of the control group. This direct relationship independent of and excluding the effect of all other predictor variables further explained that lower extent of fatigue had direct influence on faster thirty-meter-dash performance score evident among these athletes. Relatively higher tolerance index observed in collinearity statistics suggested that, moderately high extent of (68%) variance in fatigue perceived by the athletes was not predicted by their perceived extents of feelings of depression and vigour. This model further explained that every 1% decrease in fatigue perceived by the athletes would lead to .897% faster thirty-meter-dash performance (refer to Beta Coefficient of fatigue, having 68% of tolerance).

Further to that, direct influence of vigour and inhibitive influence of depression evident among the athletes of the control group implied that those who had relatively less feelings of vigour, but higher feelings of depression, they were evident as capable of producing relatively faster thirty-meter-dash compared to their counterparts having higher extent of fatigue, and lower extent of depression, but higher extent of vigour. Thus, findings from this Table 3B implied that among the athletes of the control condition, those who perceived lesser extent of fatigue, but had relatively higher extent of feelings of depression and vigour, they could display faster thirty-meter-dash performance. Here fatigue emerged as the most important predictor for thirty-meter-dash performance, which implied that, if athletes feel lesser extent of fatigue, irrespective of their level of depression and feelings of vigour, they can display faster thirty-meter-dash performance.

Precisely for athletes of control condition lower level of depression (refer to table *3a*) and fatigue (refer to table *3b*) were evident to predict faster thirty-meter-dash performance, which convinced us to look into the mediator roles of other associated predictors, if any, on the dash performance outcomes. As in model ***a1*** higher extents of tension and vigour were observed to contribute on faster dash performance, at the post-intervention phase (refer to model ***a2***), lower vigour and higher depression were evident to influence faster dash performance. Here in both phases of evaluation, negative mood factors (excepting vigour) appeared to be associated with dash performance, which, however, did not have any inhibitive impacts on dash performance. As no improvement in dash performance across the phases of evaluation was evident, these predictive relationships emphasized significance of introduction of interventions in improving athletic skills[27,28,35,57]. In our opinion, higher extent of negativity (as lower depression along with high feelings of tension and vigour in model ***a1*** and lower fatigue along with high feelings of depression and lower extent of vigour in model ***a2***) created the problem of perceived helplessness among athletes of control condition, and as they did not receive any intervention training, their mood states did not improve, which further deteriorated their performance[4,5,27,28,34,35,57].

Findings from Table 4a clarified unique contribution of confusion on the thirty-meter-dash score evident among the VMBR trainee athletes at the pre-intervention phase of analysis. This direct relationship explained that lower extent of confusion had direct influence on faster thirty-meter-dash performance score evident among the athletes who were assigned to VMBR training. Since no other predictor variable was found associated with the dependent measure of thirty-meter-dash performance, the tolerance index observed in collinearity statistics, however, suggested that total extent of (100%) variance in perceived confusion was not predicted by any other variables. This model further explained that every 1% reduction in confusion evident among the athletes would lead to .657% faster thirty-meter-dash score (refer to Beta Coefficient of confusion, having 100% of tolerance).

Findings from Table 4b clarified unique contribution of anger on the thirty-meter-dash score evident among the VMBR trainee athletes, which was obtained at the post-intervention phase of evaluation. This direct relationship explained that lower extent of anger had direct influence on faster thirty-meter-dash performance score evident among the athletes who received VMBR training. In absence of other predictor variables, as the tolerance index observed in collinearity statistics suggested, total extent of (100%) variance in anger perceived by the athletes was not predicted by any other variables. This model further explained that every 1% decrease in anger evident among the athletes would lead to .693% faster thirty-meter-dash score (refer to Beta Coefficient of anger, having 100% of tolerance).

Athletes of VMBR intervention condition were evident to have feelings of lower level of confusion (refer to table *4a*) and anger (refer to table *4b*), which facilitated in faster thirty-meter-dash performance. Model ***b1*** clarified that, at the pre-intervention phase, athletes having lower extents of confusion, had faster dash performance, while during the post-intervention phase (refer to model ***b2***), those who perceived lesser anger, they were evident to display faster dash performance. Alike what was evident among athletes of control condition, hereto in both phases of evaluation, negative mood factors appeared to be associated with dash performance, which, however, facilitated thirty-meter-dash performance. As VMBR training resulted in substantial improvement in dash performance, could be that those who perceived lower level of anger at pre-intervention phase, they got more benefitted by the VMBR intervention, and could display faster dash performance. Since, the mood assessment was not done at the post-intervention phase of assessment, improvements in mood states, if any, owing to VMBR training could not be ascertained. As it could be hypothesized, feelings of lower level of anger to a certain extent may have facilitative impacts on athletic performance[4,5,57], hence that perhaps helped the VMBR trainees to resolute to put extreme efforts to excel in performance[4,5,57].

Outcomes of the Table **5A** clarified unique contribution of Fatigue (model ***c1***) on the thirty-meter-dash performance score evident among the biofeedback trainee athletes, which was obtained at the pre-intervention phase of evaluation. The direct contribution of fatigue further explained that lower extent of fatigue contributed to faster thirty-meter-dash performance among these athletes. In this case as well, absolute extent of (100%, see tolerance index) variance in perceived fatigue was not predicted by any other mood factors. This model further explained that every 1% perceived reduction in fatigue would lead to .546% faster thirty-meter-dash (refer to Beta Coefficient of fatigue).

Outcomes of the Table **5B** (model ***c2***) on the other hand, clarified unique contribution of depression on the thirty-meter-dash performance score evident among the biofeedback trainee athletes, which was obtained at the post-intervention phase of evaluation. The indirect relationship, however, further explained that independent of and excluding the effect of all other predictor variables, lower extent of depression contributed to slower thirty-meter-dash score evident among these athletes. Higher tolerance index observed in collinearity statistics suggested that, very high extent of (89.7%) variance in depression perceived by the athletes was not predicted by their perceived level of confusion. This model (model ***c2***) further explained that every 1% perceived increase in depression by the athletes would lead to .708% faster thirty-meter-dash (refer to Beta Coefficient of depression, having 89.7% of tolerance).

Besides the previous analyses, direct influence of feeling of confusion evident among the athletes of this group implied that those who had relatively lower extent of feelings of confusion, they were evident as capable of producing relatively faster thirty-meter-dash compared to their counterparts having higher level of confusion. Thus, findings from this Table **5b** (model ***c2***) implied that among the athletes who received biofeedback training, at the pre-intervention phase of analysis, those who perceived higher extent of depression, but had relatively lower extent of confusion, during the post-intervention phase of analysis, they could display faster thirty-meter-dash performance.

Among biofeedback trainee athletes, at the pre-intervention phase, those who had lower level of feelings of fatigue (refer to table *5a*), they could display faster dash, while the post-intervention relationship implied higher feelings of depression and lower level of confusion (table ***4b***), were associated with faster thirty-meter-dash performance. Model ***c2*** thus clarified that, biofeedback training perhaps helped those athletes to cope with their heightened feelings of depression and to regulate their level of confusion, and those modifications resulted in faster dash performance. If the assessment of mood could be performed during the post-intervention phase of assessment, improvements in mood states due to biofeedback intervention could be substantiated. Nonetheless, it could be postulated that, along with modifications in autonomic adaptations, biofeedback training could modify negative feelings in desired extent, which may have facilitated performance of athletic skills[4,5,23,27,28,34,35,57,71,72].

In sum, this study proposes corroborative evaluation of psychobiological indices and transient mood factors and emotional make-up of the athletes,[23,27,28,34,35,57,71,72] who underwent differential types intervention training[4,5,27,28,34,57]. Besides that, action-oriented VMBR intervention was not effectively employed in RCTs on athletic performance as yet, and hence, efficacy of VMBR could not be well investigated and appreciated[43-45]. Furthermore, pre-and-post intervention analysis of transitory mood factors accompanied by evaluation of inner core emotionality and associated autonomic phasic indices could provide more authentic information on intricate processes ensuing agile athletic performance.

5. CONCLUSION

The findings of this study confirmed the effectiveness of both the therapeutic regimes though in inducing a faster thirty-meter-dash performance, differences between the VMBR and biofeedback intervention techniques were not evident. VMBR training helped the athletes reducing their confusion, regulating their anger and facilitated the faster thirty-meter-dash performance. Biofeedback training helped to regulate the higher depressive feelings, lower levels of fatigue and confusion, which perhaps resulted in a faster display of thirty-meter-dash performance. Athletes of control condition, however, could not display faster thirty-meter-dash performance. They had a lower extent of fatigue, high depression and lower level of vigour, which perhaps caused more difficulty in regulating themselves and displaying faster thirty-meter-dash performance.

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7. CONTRIBUTION OF AUTHORS

Conceived and designed the experiments: SoS, SrS
Collected data and performed the experiments: FaS, FoH, MaA, SoS, SrS
Contributed with materials/analysis tools: SrS, SoS, HaH
Analysed the data: FaS, SoS. SrS
Wrote the manuscript: SrS, SoS
Checked and edited the format of the paper: SoS, SrS, HaH, FaS
Final approval: SoS, SrS, HaH

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Process of Acceptance for SECTION IV articles (Articles on Sports and Exercise Science)

Article ID	Reviewer	Affiliation	Assigned as	Decision
MS-BD50-Res-Exp. Sp. and Exercise Sc - 1	Dr. Debashish Chowdhury	Sport Physician and Asst. Gen. Manager, Bangladesh Cricket Board, Dhaka, Bangladesh	First reviewer on March 8th 2021	Accepted with minor change
	Dr. Dilsad Ahmed	Research Coordinator University of Macau, Macau, Guangdong, China	Second reviewer on March 18th 2021	Accepted after major Change
	Dr. Miftakhul Jannah	Professor, Training and Education Development Centre State University of Surabaya Surabaya, Indonesia	Final reviewer on April 3rd 2021	Accepted for publication on 26th August 2021

Article ID	Reviewer	Affiliation	Assigned as	Decision
MS-BD50-Res-Exp. Sp. and Exercise Sc - 2	Dr. Maibam Chourjit Singh	Asso. Prof. Department of Physical Education & Sport Sciences, Manipur University, Canchipur, Manipur, India	First reviewer on March 10th 2021	Accepted with minor change
	Dr. Debashish Chowdhury	Sport Physician and Asst. Gen. Manager, Bangladesh Cricket Board, Dhaka, Bangladesh	Second reviewer on March 28th 2021	Accepted after major Change
	Dr. Miftakhul Jannah	Professor, Training and Education Development Centre State University of Surabaya Surabaya, Indonesia	Final reviewer on April 23rd 2021	Accepted for publication on 24th August 2021

Article ID	Reviewer	Affiliation	Assigned as	Decision
MS-BD50-Res-Exp. Sp. and Exercise Sc - 3	Dr. Dilsad Ahmed	Research Coordinator University of Macau, Macau, Guangdong, China	First reviewer on March 16th 2021	Accepted with minor change
	Dr. Maibam Chourjit Singh	Asso. Prof. Department of Physical Education & Sport Sciences, Manipur University, Canchipur, Manipur, India	Second reviewer on March 27th 2021	Accepted after major Change
	Dr. Miftakhul Jannah	Professor, Training and Education Development Centre State University of Surabaya Surabaya, Indonesia	Final reviewer on May 3rd 2021	Accepted for publication on 27th August 2021

Article ID	Reviewer	Affiliation	Assigned as	Decision
MS-BD50-Res-Exp. Sp. and Exercise Sc - 4	Dr. Debashish Chowdhury	Sport Physician and Asst. Gen. Manager, Bangladesh Cricket Board, Dhaka, Bangladesh	First reviewer on March 19th 2021	Accepted with minor change
	Dr. Maibam Chourjit Singh	Asso. Prof. Department of Physical Education & Sport Sciences, Manipur University, Canchipur, Manipur, India	Second reviewer on March 28th 2021	Accepted after major Change
	Dr. Miftakhul Jannah	Professor, Training and Education Development Centre State University of Surabaya Surabaya, Indonesia	Final reviewer on May 25th 2021	Accepted for publication on 29th August 2021

Finalised by the Guest Editors

Name of the Section Guest Editors	Affiliation of the Section Guest Editors	E- Signatures of the Section Guest Editors
Prof. Dr. Asok Ghosh	Professor, Faculty of Sports Science, RKMV University, Kolkata, India	
Dr. Naresh Bhaskar Raj	HOD & Senior Lecturer, School of Rehabilitation Sciences, Faculty of Health Sciences, Univ. Sultan Zainal Abidin, Terengganu, Malaysia