A STUDY ON COORDINATION TRAINING INTERVENTIONS BY PROCEDURAL MEMORY AND IDEOMOTOR PERFORMANCE AMONG RECREATIONAL ATHLETES WITH COORDINATION DEFICIENCY/DISORDER IN MALAYSIA AND BANGLADESH

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADC	Adult Developmental Coordination Disorder Checklist
ADHD	Attention deficit hyperactivity Disorder
ANOVA	Analysis of Variance
APMR	Abbreviated Progressive Muscle Relaxation
AS	Aspergers Syndrome
Beery VMI-5	Beery-Buktenica Development Test of visual motor Integration
BG	Blood Glucose
BG – II	Bender-Gestalt II
BG Test	Bender-Gestalt Test
BISS	Bangladesh Institute of Sports Sciences
BMI	Body Mass Index
BSIQ	Body self-image questionnaire
CD	Coordination deficiency
DCD	Developmental Coordination Disorder
DCDQ	Development Coordination Disorder Questionnaire
DD	Developmentally Disabled
DEM	Development Eye Movement Test
DLD	Developmental Language Disorders
DLPFC	Dorsolateral Prefrontal Cortical
DSM -IV	Diagnostic and Statistical Manual of Mental Disorders - IV

EMG	Electromyography
FMPT	Functional Movement Power Training
FMT	Functional Movement Training
FU	Follow - Up
GSR	Galvanic Skin Response
H_A	Alternative Hypothesis
H_O	Null Hypothesis
HR	Heart Rate
HRmax	Heart Rate Maximum
HRQoL	Health Related Quality of Life
HUSM	Hospital Universiti Sains Malaysia
IQ	Intelligence Quotient
ITPA	Illinois Test of Psycholinguistic Abilities
K-DTVP-2	Korean Developmental Test of Visual Perception
KK	Klinik Kesihatan
MABC	Movement Assessment Battery for Children
M-ABC-II	Movement Assessment Battery for children II
MG	Megabyte
MHz	Megahertz
MLD	Motor Learning Difficulties
mm	Millimetre
MMSE	Mini-Mental State Exam
MOA	Memorandum of Agreement
MOH	Ministry of Health

MPF	Mean Power Frequency
MVC	Maximum Voluntary Contraction
MYR	Malaysian Ringgit
NA	Not Available
NE	North-East
NH	Nonhandicapped
NTT	Neuromotor Task Training
NW	North-West
PE	Physical education
PEDro	Physiotherapy Evidence Database
pg	Page
PMT	Perceptual-motor therapy
PPSK	Pusat Pengajian Sains Kesihatan
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomized Control Trial
RM	Repetition Maximum
RMS	Root Mean Square
ROM	Range of Motion
RT	Reaction Time
RT	Resistance Training
Sc	Skin Conductance
SD	Standard Deviation
SE	South-East

secs	Seconds
SEMG	Surface Electromyography
SFQ	Short feedback questionnaire
SMT	Sensorimotor Training
SOT	Sensory Organization Test
SPSS	Statistical Package for the Social Sciences
SW	South-West
TEMP	Temperature
TGMD	Test of Gross Motor Development
TVPS-R	The test of visual perceptual skills-revised (TVPS-R)
US	Unites States
USD	US Dollars
USM	Universiti Sains Malaysia
WHO	World Health Organization
ZCR	Zero Crossing Rate

KAJIAN MENGENAI INTERVENSI LATIHAN KOORDINASI OLEH KAEDAH MEMORI DAN PRESTASI IDEOMOTOR DI KALANGAN ATLET REKREASI YANG MENGALAMI DEFISIENSI/GANGGUAN KOORDINASI DI MALAYSIA DAN BANGLADESH

ABSTRAK

Kajian semasa bertujuan untuk membandingkan keberkesanan elektromilografi (EMG)- dibantu oleh latihan motor persepsi (PMT), latihan koordinasi konvensional (CCT) dan gabungan kedua-dua intervensi (CI) dalam meningkatkan tahap kaedah memori dan prestasi ideomotor dikalangan atlet rekreasi dewasa yang mengalami defisiensi koordinasi (CD). Kajian ini dijalankan dalam dua kumpulan eksperimen yang berbeza dari dua negara yang berlainan. Seramai empat puluh orang peserta dewasa muda (18-24 tahun) dari Malaysia (N = 40) dan lapan puluh orang peserta dari Bangladesh (N = 80) telah disaring mengikut kriteria pemilihan yang sama dan dipadankan mengikut tahap CD. Peserta dalam kedua-dua negara dikategorikan secara rawak kepada empat kumpulan (satu kawalan dan tiga kumpulan eksperimen, dengan n = 10 / kumpulan di Malaysia dan n = 20 / kumpulan di Bangladesh). Kumpulan kawalan (Gr. I) tidak menerima sebarang intervensi, Kumpulan II menerima CCT; Kumpulan III menerima latihan EMG-PMT dan Kumpulan IV menerima CI. Para peserta menjalani analisis pra-intervensi dan dinilai mengikut struktur masing-masing berdasarkan sejauh mana koordinasi dua hala dan silang yang sedia ada; penyesuaian visual-motor; ketangkasan; ketepatan motor; masa reaksi yang mudah (siri); masa reaksi kompleks (pilihan); parameter neuropsikologi kognitif dan indeks keupayaan otot sebagai faktor penting untuk

penilaian kaedah memori dan kecekapan prestasi ideomotor yang berkaitan dengan prestasi yang diselaraskan. Para peserta daripada kumpulan eksperimen diperkenalkan dengan latihan intervensi mengikut kumpulan. Protokol intervensi dijadualkan selama 15-20 minit / hari; 2 hari / minggu; selama 16 minggu. Protokol intervensi mengikuti empat tahap kesukaran yang berbeza. Tahap kesukaran akan meningkat untuk semua rejim intervensi, seperti sesi 15 minit diikuti oleh dua tahap kesukaran yang pertama, manakala untuk tahap kesukaran ketiga dan keempat, protokol intervensi berterusan selama 20 minit setiap sesi. Sesi intervensi dijalankan selama dua hari seminggu dengan setiap sesi dijarakkan oleh tiga ke empat hari. Penilaian intervensi pertengahan dilakukan setelah intervensi minggu ke-8 selesai. Selepas itu, intervensi diteruskan selama 8 minggu lagi (minggu ke-16 penilaian dilakukan). Selepas 12 minggu paska intervensi, susulan penilaian dilakukan untuk mengesahkan tahap kelestarian intervensi. Pengukuran ANOVA berulang dua hala menunjukkan kaitan signifikan peningkatan ketara kawalan motor sebelah kiri dan kanan, dalam arah jam dan lawan arah jam, pada hasil Indeks Purata Zero-Crossing Rata-Spektrum EMG, dalam peningkatan pemahaman kognitif dan memori kerja yang jelas antara peserta Malaysia dan Bangladesh bagi kumpulan eksperimen. Kajian menunjukkan bahawa bagi peserta Malaysia dalam kes kaedah memori, CCT merupakan teknik intervensi yang paling berkesan, diikuti CI. Bagi peserta Bangladesh, dalam meningkatkan kaedah memori, EMG-PMT dikenalpasti sebagai teknik intervensi yang paling berkesan, diikuti oleh CCT (parameter koordinasi motor dan pergerakan) serta CI (parameter kognitif dan EMG). Bagi prestasi ideomotor dimana, majoriti parameter EMG-PMT dikenalpasti sebagai teknik intervensi yang paling efektif.

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ABSTRACT

Present study intended to compare the efficacy of electromyography (EMG)-assisted perceptual motor training (PMT), conventional coordination training (CCT) and combination of both interventions (CI) in improving the level of procedural memory and ideomotor performance in young-adult recreational athletes identified as having coordination deficiency (CD). This study was carried out in two different experimental set-ups and in two different countries. Forty young-adult participants (18-24 years) from Malaysia (N = 40) and eighty participants from Bangladesh (N = 80), were screened following identical selection criteria and were matched according to extent of CD. Participants in both set-ups were randomly categorized into four groups (one control and three experimental groups, with n = 10/group in Malaysia and n = 20/group in Bangladesh). Control group (Gr. I) participants did not receive any intervention, Group II participants received CCT; Group III received training of EMG-PMT and Group IV participants received CI. Thereafter pre-intervention analyses were carried out in both set-ups, based on bilateral & cross-lateral coordination; visual-motor conditioning; dexterity; simple and complex reaction time; cognitive parameters and muscle-potentiality indices as factors for procedural memory and ideomotor performance associated with coordinated performance. Thereafter participants of the experimental groups were introduced to their respective intervention training. Protocol for the interventions was scheduled as 15-20

minutes/day; 2 days/ week; for 16 weeks, followed by gradual and identical increment in difficulty level (15 minutes/session first two levels, 20 minutes/session for 3rd and 4th difficulty-levels). After 8 weeks of intervention, mid-term evaluation was carried out, and after 8 more weeks of intervention, post-intervention assessment was carried out at the end of 16th week. After 12 weeks of no intervention, post follow- up assessment was done to verify the extent of sustainability of the interventions. Two-way repeated measure of ANOVA revealed significant improvement in left and right lateral motor control, in clockwise and counter-clockwise movements, in outcomes of EMG Average-Spectrum Zero-Crossing Rate index, in cognitive comprehension and working memory, which were evident among both Malaysian and Bangladeshi participants of experimental groups. For Malaysian participants, in case of both procedural memory and ideomotor performance, CCT emerged as the most effective intervention followed by the CI. For Bangladeshi participants, EMG-PMT was identified as most effective intervention in improving procedural memory followed by both CCT (for motor and movement coordination) as well as CI (for cognitive and EMG parameters) techniques. In case of ideomotor performance, EMG-PMT was identified as most effective intervention technique.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Human being in life-endeavour matures through abundant processes of modifications, which eventually brings forth relatively permanent changes in behaviour. In behavioural science terminology, these processes are referred to as learning, which are characteristically contingent up on perceptual-cognitive appraisal of environmental cues or stimulation, and consequently manifestations of goal-directed behaviour occur. Alike other developmental learning, in physical activity set-ups, motor educability or learning is significantly relevant, which comprises a set of cognitive processes. Adequate appraisal of these cognitive schemas or processes enables an individual performer to restructure his/her motor efficiency into repetitive skill-acquisition and enhancement processes. These enhancements in motor efficiency bring forth subsequent relatively stable modifications in motor behaviour (Glencross, 1993).

Genetic predispositions required to perform efficient motor activities determine the motor ability of any individual performer (Zahradnik & Korvas, 2012), which obviously varies amongst individuals. Higher-order of motor ability leads to enhancement in motor skills and coordination, which enable an individual to engage in performance of day-to-day essential chores and active daily living conveniently and without any hindrance. Effective motor coordination enables an individual to acquire the skills required to meet all the vital needs of life. Impairment of coordination can lead to disruption in development of daily habitual activities since childhood. According to American Psychiatric Association (1994), about 6-13 % of children of school-going age, face with problems pertaining to movement or motor coordination (American Psychiatric Association, 1994; Kadesjö and Gillberg, 1999). Hereafter, conceptual background of motor coordination; problems pertaining to motor coordination and inherent processes and the therapeutic management techniques have been discussed in different sub-sections.

1.1.1 Motor Coordination

Prior to focus on the concept of motor coordination deficiency, little emphasis on the phenomenon of motor coordination is given. Coordination is referred to as the process of combined and effective interactions between various systems of the body, to function together in formulating an action toward a desired goal (Bernstein, 1967; Salter et al., 2004). In human, this process is evident in aligning different parts of head, body and extremities in relation to the circumstances and environmental challenges faced by the individual. Synchronized movements of the head, body and limbs at an intended time during the performance of skill can be assessed to evaluate the movement characteristics of that skill. An appropriate combination of movements of various body parts is essential in achieving an effortless and flawless movement. These sequential actions in response to the kinetic (i.e., force) and kinematic (viz., spatial direction) action of the muscle in any direction are termed as coordination (Schunk et al., 2004).

Motor coordination up to the recreational level of sports performance may refer to an ability to accomplish some considerably tough spatio-temporal movements faster and with adequate accuracy (Salter et al., 2004). Here, motor coordination abilities are considered as overt manifestation of motor control and regulation of motor processes of the central nervous system (Zahradnik & Korvas, 2012). The complex nature of motor coordination abilities may be well understood, based on the sub-component group of basic coordination abilities, viz., adaptive ability; balance; kinaesthetic differentiation ability; Rhythm sense; orientation and combinatory ability (Zahradnik & Korvas, 2012).

1.1.2 Coordination Disorder

All those previously mentioned elements of motor coordination are associated with each other, but still those could be trained separately. Unless a player gets conditioned or habituated with majority of the sub-components of movement coordination, deficiencies in coordination tasks become obvious in almost all the activities (Missiuna & Pollock, 1995; Schoemaker et al., 2001). Precisely, coordination deficiency may appear subtle in gross-motor skills activities, associated with balance, gait (Deconinck et al., 2006; Geuze et al., 2001), reaction ability (Saha et al., 2012; 2013 and 2015a and Zahir et al., 2016a & b) and laterality (Saha et al., 2016a & b; Zahir et al., 2016a; b & c) and with fine-motor skills deficits, such as, dexterity (Zahir et al., 2016b) etc. precision tasks (Rogers et al., 2003; Smits-Engelsman, Niemeijer, & van Galen, 2001) as well.

Previous researches although confirmed that coordination deficiency affect performance both requiring gross and fine motor skills, this inhibitive impact of deficiency in coordination however is not universally accepted phenomena. This is so stated as Case-Smith (1995), failed to find a strong relationship between motor impairment and physical activity performance. Rodger and his colleagues (2003) thoroughly investigated on this disparity in coordination deficiency related research outcomes, and they postulated that the possible reason for this inconsistent finding could be attributed to the variations in evaluation protocols, performance parameters, cross-cultural disparity and parental perceptions of the parents etc (Rodger et al., 2003). Most of the other recent researchers, however could establish connections between impairment of motor activities and physical activity performance and performance of daily activities as well (Mandich, Polatajko, & Rodger, 2003; May-Benson et al., 2002; Missiuna, Moll, King, & Law, 2007; Rosenblum, 2006).

1.1.3 Ideomotor Performance Process

Basically, coordination deficiencies (or disorders) are susceptible to delimit physical performance requiring both gross and fine motor skills, and thus those discordant motor movements cause disruptions in successful performance of goal-directed behaviour. Human behaviour in general is characterised as goal-directed and more obviously in performance of sports skills, those are goal-directed and mostly anticipative as well. In sports set-ups, the stimuli arising out of competitive environmental situations are mostly uncertain in nature and hence cannot be predicted. Thus, most of the actions can not merely be direct responses, but obviously those are supposed to be selected based on anticipated action goal. This unique process of spontaneous selection of appropriately anticipated action goals are extensively researched in cognitive psychology (Nikolaev et al., 2008; Nattkemper et al., 2010; Pfister and Janczyk, 2012). These cognitively mediated selections of anticipated actions are referred as ideomotor performance process (Shin et al., 2015).

This ideomotor performance is an instinctive and spontaneously generated bodily movement, which is mostly unconscious or made in response to a thought or idea rather than to a sensory stimulus (Koch et al., 2004; Mayr and Buchner, 2007 and Thomaschke, 2012). Ideomotor mechanisms identify the cognitive process involved in the selection of the action. Activation of the movement takes place in accordance with the response effects and anticipation of this response effects, acts as a stimulus to the motor cortex. Here it should be acknowledged that the main distinction between motor processes and ideomotor processes is that, motor process interprets control of movement, according to different parameters of movement (Schmidt & Lee, 1999). Ideomotor processes on the contrary, are more concerned about selection of movements and the cognitive aspects of movements, rather than the actual execution of movements.

To discuss on ideomotor processes, Koch and colleagues (2004) proposed the concept of embodied cognition that explains how the perceptual and motor systems of a player interacts with the external environment. Based on the embodied cognition, the ideomotor process regulates the cognitive mechanisms to select the voluntary action (Koch et al., 2004). Thus, according Koch and coresearchers (2004), human actions in sport set-ups are cognitively represented in terms of their anticipated response effects and the corresponding movement is activated by the mental cue provided by the anticipation. As Thomaschke (2012) hypothesized, the cognitive mechanism associated with ideomotor process involves motor-visual priming, which signifies that the response to one perceptual pattern is influenced by another previously exposed stimulus.

Motor-visual priming is an implicit memory process, which is essentially unconscious process. This priming could be both positive, which speeds up processing, and negative that lowers the speed of information processing (Mayr and Buchner, 2007), and perceptual (Biederman and Cooper, 1992) and conceptual (Vaidya et al., 1999) in nature. As conceptual priming is vital in semantic tasks, in sports perceptual priming plays the significant role, as it gets enhanced by the cognitive-perceptual information associated with similarity in the previous and later movements (Biederman and Cooper, 1992). Recent cognitive neuroscience investigations revealed that the processing of perceptual priming gets regulated by the extra striate cortex, while the left prefrontal cortex is associated with the conceptual priming (Dehaene et al., 1998; Guy, 2008 and Moldakarimov et al., 2010). In sports field however, positive as well as perceptual (based on similarity in form) motor-visual priming are required, which are supposed to enable the players to fasten the processing of almost identical (perhaps ipsilaterally or contralaterally) stimuli as fast as possible (Saha et al., 2012; 2015a; 2016a & b; Zahir et al., 2016a; b & c). While negative priming is supposed to slow down the processing, which gets further worsened, if conceptual priming (which searches for semantic or rational similarity) takes place (Saha et al., 2013; 2016c; Zahir et al., 2016b & c).

In psychology and sport psychology researches, obvious example of positive perceptual motor-visual priming is evident in faster and effective reaction time performances, in which movement occurs in a set of motor planning process (Wong et al., 2015). Other researchers such as Ziessler (1998) and Ziessler and Nattkemper (2001) emphasized the formation of S-R (i.e., stimulus - response) associations as prominent ideomotor function paradigms, as that is evident in serial response time paradigm (Nissen and Bullemer, 1987). Substantial extent of experimental evidences examined the patterns of planning involved in selection and initiation of actions as supports for the ideomotor performance, while participants were engaged in choice-reaction tasks (Toner and Moran, 2015). Apart from these experimental paradigms, additional direct experimental access to ideomotor cognition and performance may be carried out following motor visual priming paradigms, in which real-time (during performance) electrophysiological evaluations could be carried out to realise the patterns of motor action planning involved in coordinative performances (Wong et al., 2015).

1.1.4 Procedural Memory

Procedural memory is a type of implicit memory, which works as unconscious process and stores information about "how to do" a skilled motor actions (Bayley and Squire, 2002). Thus, it differs from declarative memory, which stores the ''what to do'' processes (Saywell and Taylor, 2008). Once a player tries to learn any newer motor skills, to encode the ''procedures'' involved in the task, procedural memory is required (Hikosaka et al, 1999). But, there exist a complex inter-relationship between these two memory processes. As researchers opined that, during the learning process, the procedural memory formed during a motor task often becomes declarative (Molinari et al., 2002; Saywell and Taylor, 2008). Systematically carried out extensive experimental trials emphasized on existence of a dynamic balance between the cortical processes followed in declarative and procedural memory systems (Eichenbaum & Cohen, 2004).

Galea and Celnik (2009) reported that, after motor skill acquisition disruption in the declarative system may be caused by inhibited dorsolateral prefrontal cortical **(**DLPFC) activation. This inhibition in DLPFC directly enhances procedural memory consolidation and subsequent recall. Parasuraman and McKinley (2014) also postulated that, alteration in balance between declarative and procedural memory systems, caused by inhibition of DLPFC can significantly accelerate procedural learning.

Evaluation of implicit procedural memory has been attempted for long-time by employing reaction-time assessment paradigms on healthy and active young-adult individuals (Nissen and Bullemer, 1987). Association between reaction time activity and procedural memory was also revealed by Ros and colleagues (2013), who reported that broadband alpha neurofeedback training enhanced activation in the motor cortex, which in turn facilitated in procedural memory leading to increased arousal and faster RT (Reaction Time). Apart from that, other researches on motor coordination related aspects revealed that, coordination training interventions enhancing posterior alpha activity in the frontal as well as parietal region (Hanslmayr et al., 2006) improved procedural memory, and hence resulted in higher-order bilateral symmetry in rotational coordinative activities (Zoefel et al., 2011). Similar enhancement in bilateral symmetry and latero-spatial coordinative performances were also evident amongst Malaysian recreational players (Saha et al., 2016a & b; Zahir et al., 2016a; b & c). Increment in posterior upper alpha power (Escolano et al., 2011) on the other hand, was observed to enhance in central region activation, which finally facilitated the working memory (Nan et al., 2012) in the active young-adult individuals.

1.2 Intervention Techniques in Enhancing Motor Coordination

Discussions in this section so far hinted up on the problems may occur due to lack of motor and movement coordination, which may encompass gross-motor skills activities, associated with balance, gait, reaction ability and laterality and with fine-motor skills deficits, such as, dexterity. In understanding the reasons behind those coordination problems, and in focusing on areas of main concern, roles of ideomotor performance processes and procedural memory processes were discussed. These two unconscious processes determine reasons behind coordination deficiency and probable ways for enhancement in coordination as well. While ideomotor process is more concerned about selection of movements and the cognitive aspects of movements, procedural memory also involves cognitive process as implicit memory, which stores information about "how to do" a skilled motor action. As both ideomotor mechanism and procedural memory processes are evident as associated with reaction time performance, choice-reaction or complex reaction performance, bilateral symmetry and latero-spatial coordinative performances and cognitive comprehension and working memory performances, enhancement in motor skills and learning processes may facilitate in ideomotor and procedural memory performances as well (Saha et al., 2016a & b; Zahir et al., 2016a; b & c). Both ideomotor mechanism and procedural memory processes are intricate unconscious mechanisms, which have shared multifaceted associations between the processes. Thus, both these processes are evident as associated with psychomotor evaluation parameters, such as, reaction time performance, choice-reaction or complex reaction performance, bilateral symmetry and latero-spatial coordinative performances (Zahir et al., 2016b & c). Furthermore, these processes are also evident as associated with cognitive comprehension and working memory performances. Enhancement in motor learning processes and skills mediated through well-designed coordination training intervention techniques, may enhance performance of the aforementioned psychomotor parameters, and in cognitive-motor performances as well, and hence those interventions may in turn facilitate in ideomotor and procedural memory performances as well (Saha et al., 2016a & b; Zahir et al., 2016a; b & c). Thus, systematically designed coordination training tailored for enhancement in activation in the motor cortex, would hypothetically result in beneficial impacts in movement coordination. Based on the "how to do" aspect and the positive-perceptual motor-visual component processes in concern, electro-physiologically-mediated real-time perceptual motor training could be planned out, which would enhance activation in motor cortex and would also modify motor planning process in the individuals having coordination deficiency. Apart from that, coordination training processes are conventionally used for motor skill enhancements during motor learning phases, but the advanced forms of those training regimes were seldom tried on recreational players. Further to that, combined introduction of electro-physiologically guided real-time activation and conventional ways of coordination training were never conceived in eliminating problems pertaining to coordination deficiency.

1.2.1 Conventional Coordination Training

Coordination training is designed to enhance the overall ability of an individual to move swiftly and gracefully. Coordination training regimes are meant to enhance in the ability to quickly and purposefully perform difficult spatio-temporal movement structures. Conventionally deigned coordination training programmes include varieties of aspects, such as – bosu – balance training exercises; mirror movements; asymmetric movements; acrobatic exercises; visuo-motor (eye-hand) coordination skills; rhythming activities; hopping and skipping ropes; drills with balls and cones etc., may improve the manner in which the person having difficulty in coordination responds to the external perturbations (Tomporowski, 2003). According to coordination training experts (Brisswalter et al., 2002; Etnier et al., 1997; Tomporowski, 2003), coordination is inborn in most of the people and people who have good coordination usually tend to be more agile than that of their counterparts who do not have a good level of coordination.

As it is well-known, the ideal period for coordination training would be during childhood or adolescent (Zahradnik & Korvas, 2012), since the individual is more enthusiastic in learning new forms of physical skills. There exists a controversy among experts and fitness trainers. Some experts argue that coordination training becomes difficult after teenage or in adulthood, but fitness trainer counteract by saying that an individual can still be trained in coordination regardless of the age

(Brisswalter et al., 2002; Etnier et al., 1997; Tomporowski, 2003). Further to that, cognitive functions of individuals develop after a coordination training session irrespective of the fitness level of the individual (Brisswalter et al., 2002; Etnier et al., 1997; Tomporowski, 2003).

1.2.2 EMG-Assisted Perceptual Motor Training

Electromyography (EMG) assisted interventions are usually focussed with biofeedback training, which has been extensively used in the analysis and rehabilitation of participants with various neurological and muscular disorders. But EMG assisted biofeedback techniques may also provide an alternate form of coordination training (Totterdell & Leach, 2001). Angoules et al., (2008) have found that EMG Biofeedback can reduce heightened musculoskeletal contractions and may provide relief from over-burdened activation of muscles, and thus enhanced regulation of muscle tension may enable a performer to coordinate movements in desired direction. Further to this regulation of muscle tension, EMG assisted intervention techniques can further help in the enrichment of the cognitive skill (Angoules et al., 2008). With an aid of EMG biofeedback, muscle activity from basic skeletal muscles can be recorded and analysed using surface electrodes (Totterdell & Leach, 2001).

Here, a little differential attention has been given to optimal evaluation of coordinated muscular movements and on the possibility of regulation of movements in the desired directions, in order to have coordinated movements. Impacts of improvements in neural networks in enhancing motor activation was proposed by Bernstein (1967) almost fifty years back, and he postulated the existence of combined interactional effects of neural mechanisms, which are susceptible to enhance in muscular activation and regulation as well, and the resultant improvement in coordinative performance. These combined interactional effects are commonly referred to as muscle synergy, which according to Torres-Oviedo and colleagues (2006), may be outcome of a single neural command signal, creating summated patterns of co-activation in muscles.

To realize specific patterns of muscle activation involved in a specific movement, integrated signals based on muscle synergies, obtained while perceptual-motor tasks are performed, could aptly be estimated by evaluation of real-time EMG (electromyography) activity (Boonstra et al., 2015). Synergistic muscular activities are integrated to form a range of motor neuronal impulses as indices of activation in muscles. These integrated EMG indices may provide valid information concerning real-time inputs pertaining to the extents of motor regulation while performance of various movements, such as walking or balancing on a beam (Torres-Oviedo et al., 2007). The debatable issue concerning whether synergistic muscle movements are outcomes of short-comings in kinematic performances, or those provide us with a set of newer neural strategy (Tresch, and Jarc, 2009), remained unanswered. Of late, Alnajjar and the coresearchers (2015), trying to clarify this issue, introduced the term of sensory synergy, and hence they postulated that, synergies are the neural strategies to handle sensory and motor systems.

Thus, it could be expected that if EMG assisted intervention techniques are being followed, those may provide optimal information concerning muscular fatigability, maximal extent of voluntary contraction, extents of average and maximal zero crossing rates. These indices may provide baseline information concerning pre-existing limitations evident in the muscles. Based on the obtained information, intra-correlational aspects pertaining to muscle synergy may be evaluated, which in turn may help the individual trainee in developing his/her personal neural strategies and can employ those information in enhancing their level of motor coordination.

1.2.3 Combined Intervention

So far in this chapter attention has been given on conventional ways of enhancing coordinative abilities or concentrating on planned intervention techniques employing electrophysiological measures to obtain integrated muscular activities tailored for perceptual-motor coordination training. These intervention techniques are designed for differential purposes, as conventional coordination training regimes are meant to enhance in the ability to perform difficult spatio-temporal movement structures, by engaging in coordination training programmes, such as –balance training symmetry-asymmetric movements, acrobatic exercises, visuo-motor (eye-hand) coordination skills training, etc. (Brisswalter et al., 2002; Tomporowski, 2003), EMG-assisted perceptual-motor training intended to realize specific patterns of muscle activation involved in a specific movement and integrated signals based on muscle synergies (Boonstra et al., 2015; Torres-Oviedo et al., 2007 and Tresch, and Jarc, 2009). There is no such available literature regarding combined effect of conventional coordination training and EMG-assisted perceptual coordination training on developing motor coordination of the sports performance in Malaysian as well as in Bangladeshi contexts. These limitations in the critical scrutiny of existing reported literatures, delimit the opportunities of methodologically compatible realistic selection of sub-components of both conventional and EMG-PMT intervention techniques in adapted development of a combined coordination intervention technique, which could be tailored for enhancement in motor and movement coordination deficiencies evident amongst Malaysian and Bangladeshi recreational athletes diagnosed as having coordination deficiencies. Hence, at this outset this research project got motivated to include another intervention plan, which would combine integrated components of conventional coordination training and EMG-assisted perceptual motor training as well, to observe whether the combined introduction can provide any differential benefits compared to the hypothesized outcomes of conventional and EMG-assisted intervention training alone.

Based on such paradigms, intervention trainings are categorized into three groups in this study. Recreational players were targeted as the participants, who were assumed to get benefitted from the information received about their physiological, psychological and psychobiological status pertaining to their problems of coordination. Therefore, in this present research study three types of coordination training were used, namely, Conventional Coordination Training; EMG-assisted Perceptual Motor Training and Combined Training of Conventional Coordination Training and EMG-assisted Perceptual Motor Training.

1.3 Problem Statement

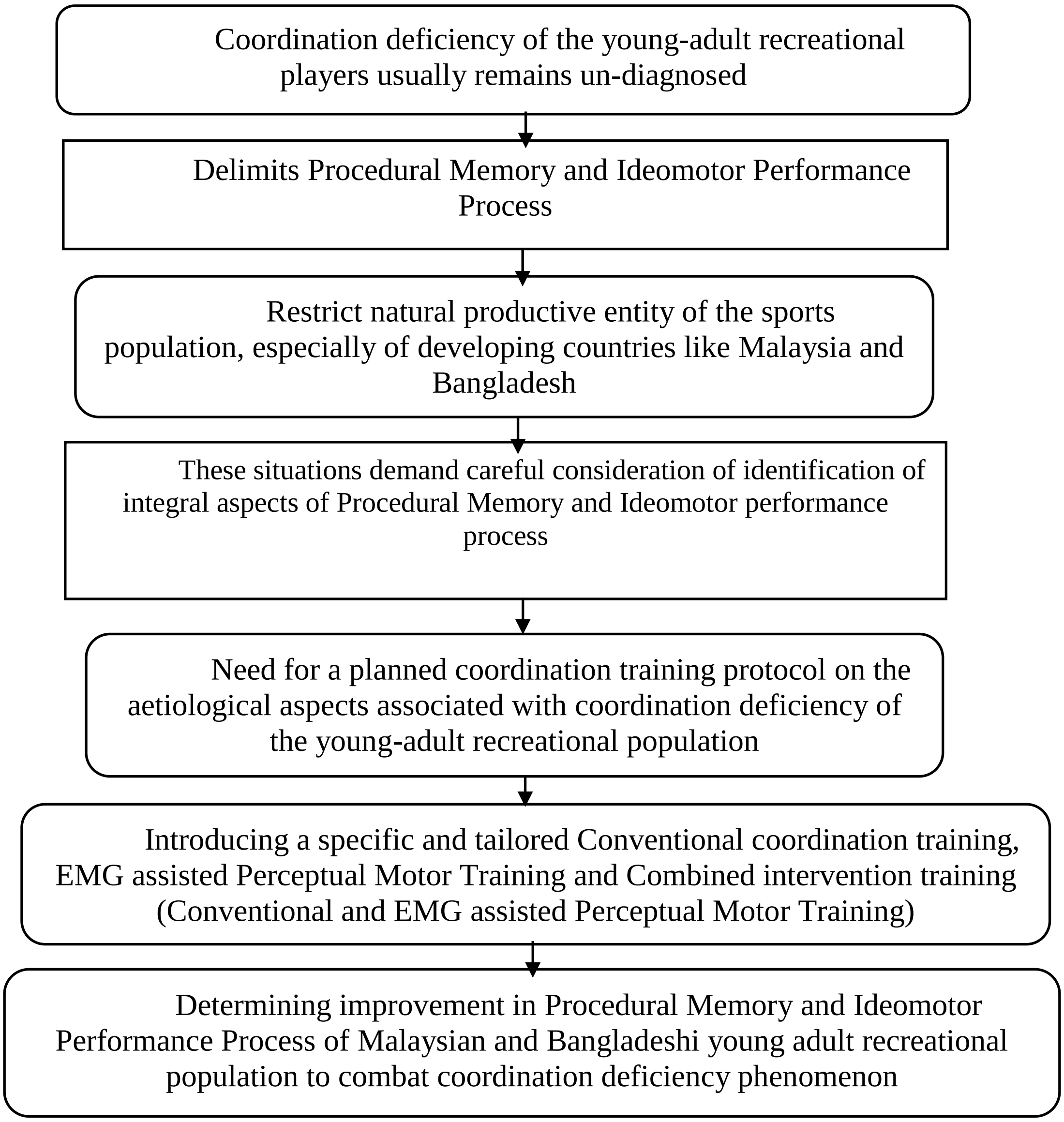
Whether differential coordination training programs have beneficial impacts on procedural memory and ideomotor performance in Malaysian & Bangladeshi young-adult recreational athletes having coordination deficiency and which program is most effective for Malaysian & Bangladeshi recreational athletes?

1.4 Rationale of the Study

Fewer studies were previously conducted to evaluate and assess different aspects of coordination deficiency observed amongst children and young-adult individuals. Experimental studies, whichever were conducted on children, the focus of the experimental paradigms was based on developmental coordination deficiency

(DCD), known as dyspraxia. Researches related to coordination deficiencies were mostly carried out in the developed countries, and more so, those were carried out based on neurobiological and neurological indices obtained from the children and young-adult population either having gross coordination deficiency or DCD. At this juncture, it seems crucial to assess the aetiological issues pertaining to commonly diagnosed coordination deficiency in normal recreational population, which usually remains un-diagnosed. Further to that, it has been noticed that, some of the otherwise normally grown-up children remains clumsy, disorganised and dysfunctional in their daily living skills, self-organization, sporting behaviour and handwriting etc. throughout their lives. These limitations in coordination prevents them to be mature and to develop themselves as productive entity and to self-actualize in their adulthood. If these disorders or deficiencies remain undetected and eventually un-treated, this may ultimately out immense pressure on the health-care system of a country as well, especially of a developing country. Having said that, no research exists on the Malaysian and Bangladeshi population to assess and recommend alternatives to enhance the quality of lives of young-adult population with coordination deficiency. Hence, the present study was conducted to assess the effectiveness of differentially planned coordination training interventions on the aetiological aspects associated with coordination deficiency, evident amongst young-adult recreation athletes having coordination deficiency in Kelantan, Malaysia and Dhaka, Bangladesh. In addition, the present study attempted to design a specific and tailored coordination training protocols, which included differential facets of both conventional and EMG assisted perceptual motor training regimes in combination, for the benefit of young-adult recreation athletes living in these two countries, evident with coordination deficiency.

1.5 Conceptual Framework



1.6 Objectives

General Objective

To identify differential efficacy of conventional coordination training and EMG-assisted perceptual motor training intervention and combination of both interventions on coordination deficiency (CD).

Specific Objectives

1. To evaluate the effect of Conventional Coordination training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

2. To investigate the effect of EMG assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

3. To determine the effect of combined intervention of conventional coordination training and EMG-assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

4. To assess on the relative impacts of conventional coordination training and EMG assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

5. To compare the relative impacts of conventional coordination training and combined intervention of conventional coordination training and EMG-assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

6. To compare the relative impacts of EMG assisted perceptual motor training and combined intervention of conventional coordination training and EMG assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

7. To determine on the comparative impacts of Conventional coordination training, EMG assisted perceptual motor training and a combined intervention of conventional coordination training and EMG assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

1.7 Research Hypotheses

The following hypotheses were formulated to achieve the objectives.

1.7.1 Null Hypothesis (H_o)

1. Conventional coordination training has no effect on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

2. EMG-assisted perceptual motor training has no effect on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

3. Combined intervention of conventional coordination training and EMG-assisted perceptual motor training has no effect on procedural memory and

ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

4. No difference between conventional coordination training and EMG-assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh exists.

5. No difference between conventional coordination training and combined intervention of conventional coordination training and EMG-assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh exists.

6. No difference between the EMG-assisted perceptual motor training and combined intervention of conventional coordination training and EMG-assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh exists.

7. No difference between conventional coordination training, EMG-assisted perceptual motor training and combined intervention of conventional coordination training and EMG-assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh exists.

1.7.2 Alternative Hypothesis (H_A)

1. Conventional coordination training has significant effect on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

2. EMG-assisted perceptual motor training has significant effect on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

3. Combined intervention of conventional coordination training and EMG-assisted perceptual motor training has significant effect on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh.

4. Difference between conventional coordination training and EMG-assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh exists.

5. Difference between conventional coordination training and combined intervention of conventional coordination training and EMG-assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh exists.

6. Difference between the EMG-assisted perceptual motor training and combined intervention of conventional coordination training and EMG-

assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh exists.

7. Difference between conventional coordination training, EMG-assisted perceptual motor training and combined intervention of conventional coordination training and EMG-assisted perceptual motor training on procedural memory and ideomotor performance in young adult recreational athletes with coordination deficiency in Malaysia and Bangladesh exists.

1.8 Significance of the Study

- This study will provide crucial evidence of benefits of integrated coordinative training on improvement in the neuropsychological components of perceptual-motor learning ability, ideomotor activity and procedural memory which in turn will enhance in the sense of self-regulation in the young individuals with coordination deficiency (CD) in Malaysia as well as in Bangladesh.

- This study may accentuate the method of combining Conventional Coordination Training and EMG assisted Perceptual Motor Training in an appropriate way to improve the efficacy of combined intervention.

1.9 Definition and Terms

- **Dexterity** –Precisely the manual dexterity is considered here, which refers to ***fine motor skill***, involving the coordination of small muscles. Dexterity in this context involves the harmonious action simulation by hands and fingers, with visual synchronization (Grissmer, 2010; Maddox, 2007 and Venkadesan et al., 2007).

- **Gross Motor Skills –** These are the fundamental motor skills, such as walking, jumping, throwing etc. These are the abilities usually acquired as part of a child's motor development during infancy and in early childhood. In gross motor skill, individual needs to use large musculature (Cools et al., 2009).
- **Laterality –** This is the term, which usually refers to the individualistic preference for one lateral side of the body-parts, especially the limbs (hands and legs) over the other. This is a spontaneous selection of most of the human being in selecting the lateral side to perform any motor task (Porac and Coren, 1981 and Rogers and Andrew, 2002).
- **Ipsilateral** – In this context of research, this term usually refers to one lateral side of the body and body-parts especially limbs of the same side as another structure. The right upper-limb or hand, for instance is ipsilateral to the right leg (Kinsbourne, 1978 and Hickman et al.,2003).
- **Contralateral** – In this context, this term refers to the opposite lateral side of another structure. Example of contralateral side of body is represented by the body-part of one lateral part contrary to the other side of the body. The right arm and left leg are represented as contralateral to each other and vice-versa (Kinsbourne, 1978; Hickman et al.,2003 and Vulliemoz et al., 2005).
- **Bilateral –** This term essentially refers to both sides of the body. Bilateral conceptually is discussed in the context of lateral symmetry or asymmetry. For human being, the left and right sides of the body may be conceptually

divided along the mid-line into approximate mirror images of each other (Kinsbourne, 1978; Hickman et al.,2003 and Vulliemoz et al., 2005).

- **Embodied cognition –** It refers to interactional process that explains how the perceptual and motor systems of a player interacts with the external environment. This is the cognitive mechanisms to select the voluntary action (Koch et al., 2004).
- **Working Memory –** It is the type of temporary storage system in our memory process. This is the short-term memory, which is also called as the rote memory that processes the incoming sensory memory (Baddeley, 1986; 2000; Nan et al., 2012).
- **Cognitive Comprehension –** This is the cognitive ability of an individual, which pertains to visual motor faster adaptation to perceptual configuration of spatial and temporal irregularities. Faster and accurate cognitive comprehension enables an individual to adapt and regulate themselves spontaneously (Morley, 2012; Sternberg, 1999).
- **A recreational athlete** can be defined as a person who is physically active but who does not train for competition at the same level of intensity and focus as a competitive athlete. He or she participates in sports to be physically fit, socially involved, and mostly to have fun (Laquale, 2009).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Generally, coordination deficiency refers to a motor skill disorder which leads to impaired abilities of motor skills in individuals that disturbs the enactment of usual activities (American Psychiatric Association, 2000). The interferences of coordination deficiency on everyday activities and performances do take a great toll on people's lives. Therefore, it has become imperative to focus on different kinds of viable interventions to tackle the difficulties faced by the individuals having coordination deficiency in the society. The survey of the existing literature showed that the studies conducted in the domain of coordination deficiencies in the context of athletic training, may broadly be divided into three categories. Firstly, the effects of conventional coordination training; secondly, the effects of EMG-assisted perceptual motor training and thirdly, the effects of both conventional coordination training and EMG-assisted perceptual motor training, on procedural memory and ideomotor performance processes evaluated by psychomotor, psychological and psychophysiological parameters. Psychomotor variables included – dexterity, motor learning ability, motor coordination and reaction ability. Whereas, cognitive comprehension, working memory and cognitive-motor functional abilities were discussed under the purview of psychological variables. Electromyography evaluation indices are discussed under the domain of psychophysiological parameter.

Based on the sub-component domains of procedural memory and ideomotor processes, this review of literatures is organized with an intention to identify the 1)