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ORIGINAL ARTICLE

THE EFFECT OF CORE STABILITY TRAINING ON SPORTS FUNCTIONALPERFORMANCES AND DYNAMIC BALANCE AMONG HEALTHY UNDERGRADUATE COLLEGE STUDENTS:A RANDOMIZED CONTROLLED STUDY	Search engine: **www.ijmaes.org**

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Abstract

Back ground and objectives: *Evidences on the impact of Core Stability Training (CST) on Sports Functional Performances (SFP) have demonstrated some positive correlation between them in few sports, however evidences lack to prove causal relationship between them, especially among normal subjects. This study attempts to investigate the effect of 'CST' on 'SFP' and Dynamic Balance among healthy undergraduate college students.****Methods:****50 Healthy undergraduate college students were selected after initial screening process. They were randomly allocated to either core stability Training Group (TG) or Control Group (CG). Subjects in TG underwent 8-weeks of core stability training, whereas the subjects in CG were given no intervention and asked to carry out their usual activities. All the subjects underwent a pre and post intervention measurements for their level of sports functional performances such as agility running, distance running, ball throwing, vertical jumping, which were measured using 'T-test', '40-Yard dash test', 'Medicine ball throw test' 'Vertical jump height test' respectively and dynamic balance was measured using YBT Functional Goniometer.* ***Results:*** *Immediately after the 8-weeks of core stability training, sports functional performances such as ability to T- agility running (p=0.022), 40-Yard running (p=0.006), vertical jump height (p=0.030), have improved significantly in Training Group compared to Control Group, except medicine ball throw (p=0.348) and dynamic balance (p=0.200).****Conclusion:****8-weeks of core stability training in healthy undergraduate college students has resulted in improved lower limb sports functional performances . This causal relationship can provide reasonable support in recommending core stability trainings in sports performance enhancement training programmes for normal subjects.*

Keywords:*Core Stability Training, Sports Functional Performances, Y Balance Test, Undergraduate College Students.*

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INTRODUCTION

Core stability training (CST) has become one of the important debates among the sports training as well as sports rehabilitation providers throughout the world during past two decades. The 'core' has been described as a box with the abdominals in the front, paraspinals and gluteals in the back, diaphragm as the roof, pelvic floor and pelvic girdle musculature as the bottom, and hip abductors and trunk rotators laterally. All these muscles have direct or indirect attachments to the extensive thoracolumbar fascia and vertebral column, which connect the upper and lower extremities. A comprehensive strengthening or facilitation of these core muscles has been widely advised as a preventive, rehabilitative and sports performance-enhancing programs[1].

Core stability is also commonly referred as 'lumbar stabilization' or 'lumbopelvic stabilization'. All these terms describe the muscular control required around the lumbo-pelvic-hip region to maintain functional ability. In short, core stability can be theoretically referred to as the 'power house' or the 'engine' of all limb movements as all the limb movements are generated from the core and translated to the extremities. Core stability is believed to serve as a muscular corset that works as a unit to stabilize the body and spine with and without the limb movements[1]. Therefore, it is theoretically believed that even if the extremities are strong and the core is weaker the decrease in muscular summation through the core might result in less force production and inefficient movement pattern both in the upper and lower extremity performances. Elite level athletes require much higher levels of core stability for sport performance than during activities of daily living[2,3,23,24]. Thus it looks obvious that core stability involves dynamic motor control and efficient transfer of huge forces from both upper and lower extremities through the core in order to enhance efficient biomechanics and sporting performance.

Large number of new equipments, products and fitness programmes are being introduced day by day into the market and keep promising quick and easy fitness solutions for our exercise deprived society. This certainly makes the sports population to believe that enhanced core stability will improve their performance level in their sports. Although strong core muscles are believed to help athletic performance, few scientific studies have been conducted to support the effectiveness of core strength training on athletic performances[4]. Few of the published literatures have demonstrated that there is a positive correlation between the core stability and functional performance in few sports; however, they were unable to bring out any causal relationship between these two variables[5]. So it is apparent that the scientific community still remains uncertain as to the relationship between core stability and sports performances. Research on core stability is severely lacking, except in the field of treatment to low back pain[1]. In few of the studies, though significant improvement in core strength has been documented as a result of core stability training (CST), the same study has failed to show significant changes in the athletic performances, this type of research indicates that CST is a useful tool for strengthening core muscles, but carryover to mechanics and performance require further investigation[4]. This is quite evident in the study done by Tse et al., who analyzed the effectiveness of an 8 week core endurance exercise protocol on college aged male rowers and reported that although their program did improve core endurance, but did not significantly improve functional performance in tests such as the vertical jump, broad jump, shuttle run, and 40 m sprint[7]. So it becomes evident that although

core training has been shown to improve core stability, the results have not translated into performance enhancement in all the sports. Some of the limitations in these studies include inconsistent methods used to measure core strength/stability or the population tested[3]; hence the role of CST, CST measurement and sports functional performances are yet to be answered quantitatively.

Core stability is also having clear link with injury prevention. Athletes who did not sustain any injury were significantly stronger in hip abduction and external rotation with external rotation being the only significant predictor of injury status[6]. So, if the relationship between core stability and sports performance is evidenced quantitatively, sports people possessing higher levels of core stability can be considered less susceptible to injury. Evidence of this kind would have major implications in clinical practice and sports specific trainings.

In regard to Core stability training protocol, It is very challenging to include a comprehensive core stability training protocol, which address strength, endurance, motor control, balance, coordination, flexibility and range of motion. Most of the previous studies on sports performance have failed on this. Moreover, the training periods were ranging from mere 4 to 6 weeks with 2 sessions per week mostly and these were admitted as insufficient and limiting factors[3,4,5,6,7,8]. In the past, in core stability training program, major emphasis was given on the strengthening of global muscles (large phasic muscles which link pelvis to thoracic cage) but recently, one of the major advances we attained in the understanding of core stability is that the core stability is improved by the contribution of both global as well as local muscles (tonic muscles that attach directly to the lumbar vertebrae), hence both group of muscles must be trained[1]. Gracovetsky has suggested that the core should include the muscles of the shoulder and pelvis because they are the critical in the transfer of forces across the body9. Synergistic activation patterns exist in pelvic and trunk controlling musculature[10]. The large cross sectional musculature in the hip region is involved in the lumbo-pelvic stabilization and also remarkable power generation during sporting activities. The gluteal muscles play a major role in stabilizing the trunk over a planted lower extremity in order to supply power for forward leg motions in movements such as throwing and running[11]. In addition to this, it is also realized that strength is not the only, nor indeed the most important, quality of muscle, but the core muscle activation and endurance are probably more important and the core stability program should reflect all this1. Stability and movement are critically dependent on the coordination of all the muscles surrounding the lumbar spine. To achieve muscular co-contraction, precise neural input and output (PNF) is needed. The importance of the neuromuscular system, as it pertains to the core, has been clarified through research specifically addressing muscle activation patterns during different sporting activities. So, it is important that core stability training must address all the components of core muscle stability such as endurance, strength, enhanced neuromuscular pathways, motor control, flexibility, balance and proprioception, which are essential for any sports activity to be enhanced. A number of evidences show that Swiss ball exercises are likely to result in better coordination of synergistic and stabilizer muscles and unstable conditions as induced by sitting on a Swiss ball can stimulate proprioceptors and enhance balance and coordination of core muscles significantly[8]. The use of Swiss ball training

either alone or an adjunct to other physical training to enhance core stability appears more promising[8]. Pressure bio-feedback device has been found to be quiet useful tool to ensure the core muscle activation during the training. This device has come into general use for stabilization exercises for all parts of the body[12]. 'Dublin games development core training activate protocol' with Mat and Swiss ball exercises to train the core stability has been found to be valid and reliable. This protocol consist 9 levels of core muscle activation and endurance exercises and 8 types of progressive Swiss ball core strength exercises[19]. Hence, this protocol attempts to address all the components of core muscle stability such as endurance, strength, enhanced neuromuscular pathways, motor control, flexibility, balance and proprioception, which are essential for any sports activity to be enhanced[1].

As far as population concerned, studies in the past were mostly conducted on various sports population using sports specific outcome measures on runners, athletes, football players, basketball players, swimmers, rowers, etc.[3,4,5,6,7,8],moreover these studies did not include general sports functional performances to address amateur college sports population who normally tend to involve in wide range of sports activities and still wants to improve the fitness level to justify their performance level. Though the sports is viewed as most fascinating and entertaining due to professional sports people, the very purpose of any sports is to be played by everyone to maintain an optimal physical and mental fitness, hence a study that focuses on this general population has become mandatory and most vital.

Since the core stability is a multi-dimensional entity, which comprises strength, endurance, flexibility, synchronous muscular control over a range (functional); hence there is no single measure available to measure core stability. In the previous studies, the outcome measures were having few flaws. 'Bridge tests' (McGill's Core stability tests) are functional however, these test reflect the static muscle stability and do not test core stability during dynamic situations13. The single-legged squat test would provide a meaningful measure of core stability to most of the sporting activities as most of the sports involve dynamic functioning on single leg stance, but the test reliability of this test has been questioned clinically by few researchers[14]. In the 'Double leg lowering test (DLL), there is a natural tendency for the pelvis to tilt anteriorly during the very early stage of the DLL maneuver. As even healthy young subjects do not appear able to prevent the tilting, the scoring system associated with the DLL test should be questioned[15, 17]. Thus all the core stability measuring tests are found with their own pitfalls. In order to avoid these pitfalls, Y Balance test can be a good alternative to reflect the outcome of core stability training since Y Balance test considers the core in functional quadrants, hence the rehabilitation and exercise professionals can have a more comprehensive appraisal of function before specific or isolated testing is performed[18]. Y Balance test uses functional goniometer to measure dynamic balance, which enable precise quantification of a person's body relative movement by simultaneously requiring strength, flexibility, and neuromuscular control, and core stability, range of motion, balance and proprioception. Hence dynamic balance measured through Y Balance test can be a suitable outcome measure to quantify the effect of core stability training programme. The dynamic balance is determined by the reach distance of the limbs in all four quadrants in YBT. The Normalized Composite Reach Distance (NCRD) is calculated by sum of the greatest reach in the

3 reach directions is divided by three time's limb length (upper & lover limb) and then multiplied by 10016. YBT functional goniometer has been found to be valid and reliable[20]. Since there is a learning effect that occurs after 4 to 6 trails, it is recommended that the client practice 4 to 6 trials on each upper limb and lower limb in all three reach directions (YBT is mainly performed in 3 directions) prior to formal testing .

In regard to Sports functional performance measures, several studies have examined the impact of core muscle training on performance outcomes with minimal success and few conclusions[5], these studies have also proposed that it is possible that performance in specific sports is highly correlated to specific measures of athletic performance.

In order to address the sporting requirement for a healthy amateur college student, it is important to include sports functional activities, which include wide range of general upper limb and lower limb sports functions. Sharrock et al. (2011) have used four simple testing methods to measure sports functional performance level in their co-relational study to see the relationship between core stability and athletic performance among sporting college students. It was attributed that although these functional tests are not the direct measures of sports performance, they still do measure factors or components of many sports. They are also found to address range of both upper as well as lower extremity sports performances. They are 'Medicine ball throw', 'T-test', '40-Yard dash', 'Vertical jump'[5].

MATERIALS AND METHODS

Study design and sampling: This study is a quantitative experimental pre and post double blinded randomized controlled study and the sample size was calculated based on the power calculation with alpha at 95% of confidence interval and beta at 80% power using prevalence rate of core stability weakness among healthy subjects. The sample size to meet the above criteria was found to be 20 per group; however, participant attrition was anticipated considering an extensive training period of 8 weeks. Hence 10 samples (5 subjects for each group) were added and the sample size was determined to be 50. This study protocol was submitted to 'Research Review Committee (RRC) of MAHSA University and obtained formal ethical board approval.

Sample selection: The subjects were healthy male and female undergraduate students and aged between 18 to 25 years of all races. The subject, who found to be professional sports players and diagnosed with any soft tissue injuries in upper & lower limb previously, any fracture or fracture healing, any systemic illness, history of abdominal, musculoskeletal, cardiorespiratory and neuromuscular injury during the past 60 days, subjects with the history of residual neuromuscular deficit, surgery to musculoskeletal, cardiorespiratory, neurological systems, any known mental disorder were excluded. Eligibility to participate physical activity was screened by using 'Physical Activity Readiness-Questionnaire' (PAR-Q).

Moreover, the subjects were also screened by a certified physician to get 'Health Clearance Confirmation' using PARmed-X Form, to confirm and ensure that they are in good health during admission and the study period.

A total of 161 students were screened for eligibility to participate in this study from MAHSA University, Malaysia and 143 students were found to be eligible (n=13 were found not meeting selection criteria; n=5 declined to participate due to other commitment). Out of 143, 50 subjects were selected randomly and informed consent was obtained. The study

subjects were randomly allocated into two groups namely Training Group and Control Group with 25 subjects in each through random sets of numbers drawn from a box.

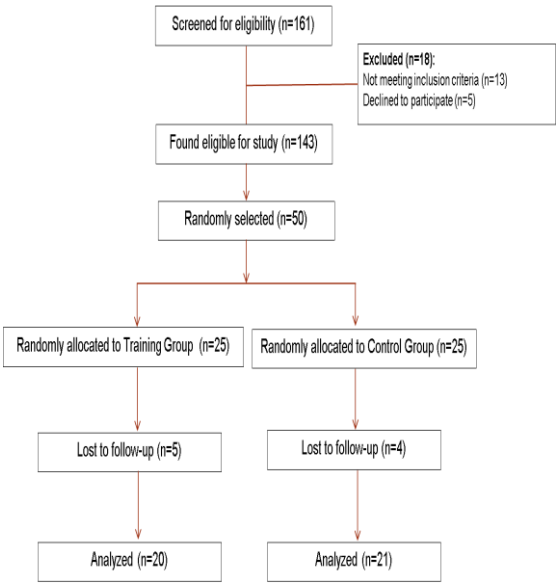


Figure 1: Flow chart of sample selection and grouping

Pre-Intervention phase: All the subjects have undergone for a familiarization session to ensure that they are comfortable with all the study measurement procedures and to minimize any learning effects. All the participants have undergone pre-intervention measurement to find out their base line level of dynamic balance using YBT functional goniometer as well as level of sports functional performance using 4 tests to address common sports activities:- Medicine ball throw test, T-test, 40-Yard dash test, Vertical jump height test.

Figure 2: T –Test (Agility running in T pathway)

Figure 3: 40 Yard Test (40 Yard distance running)

Figure 4: Medicine ball throw (weight-2 Kg)

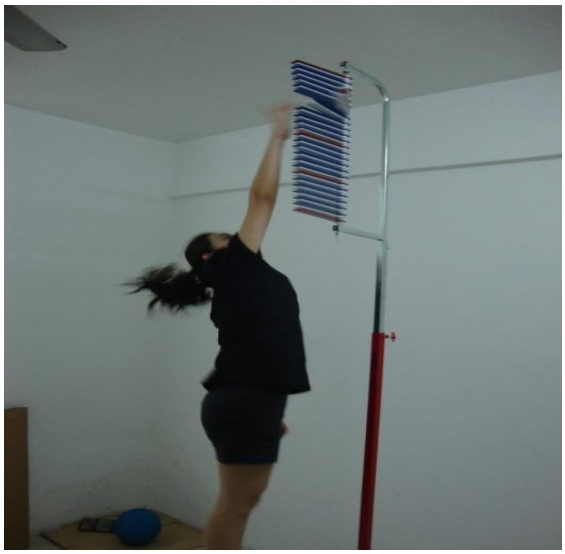


Figure 5: Vertical high Jump (Vertec)

Each subject was rotated to each of the testing stations randomly. Each test was performed in random order three times and the best score was taken into account. Prior to the test measurement, the assessors at

each station have given a brief instruction individually to each subject on the testing procedure and proper technique to be performed during the testing. Following instruction, subjects were given a practice trial at each testing station in order to allow the subject to acclimate and understand how to perform the test and allow for the best performance possible. The assessors were not allowed to give no other feedback except to correct improper technique. Each subject was given 4 minutes of rest period following the practice trial before the first recorded performance and 4 minutes of break between each testing station in order to allow for adequate recovery. While measuring dynamic balance using YBT Functional Goniometry, since there is a learning effect that occurs after 4 to 6 trails, the participants were asked to practice 4 to 6 trials on each upper and lower extremities in all three reach directions (YBT is mainly performed in 3 directions) prior to formal testing.

Figure 6: YBT Functional Goniometer – Dynamic Balance of Upper Quarter

Figure 7: YBT Functional Goniometer – Dynamic Balance of Lower Quarter

Along with this each subjects' demographic data such as age, sex, race were recorded and BMI was measured to have a sub analysis to see whether these factors influence the level of improvement in the core stability as well as sports functional performances. All the participants were also be given a short questionnaire before and after the training period, which included questions in regard to their level of cognitive awareness on core stability, improvement in the state of body postures and level of ease felt while carrying out ADLs, to analyse the qualitative effect of core stability training.

All measurements were done by 3 trained physiotherapists with minimum of 10 years of experience in the field. Before the commencement of the study, a training session was conducted on the methods of all the outcome measures to all the assessors in order to ensure uniformity in their skill. Physiotherapists who involved in the core stability training and those who involved in data collection were kept to be different. So, totally 7 physiotherapists participated in the study. In this study, the assessors and the participants were blinded to prevent possible bias.

Intervention phase: The participants in 'Training Group' have undergone an 8-week of ''Dublin games development core training activate protocol' integrating Mat and Swiss ball exercises**.** The training programme consisted 3 sessions per week for 8 weeks, so totally there were 24 sessions. Each session lasted for about 40 minutes, which included 10 minutes of warm-up and 10 minutes of cool down exercises before and after the training session respectively. Pressure bio-feedback device was used during the training of core muscle activation.

The core stability training program was conducted by four physiotherapists with minimum of 10 years of experience in the field. Before the commencement of the study, a training session was conducted on the methods of core stability training to all the trainers in order to ensure standard and uniformity in their skill.

FIGURE 8: Core stability training sessions – Mat activities

FIGURE 9: Core stability training sessions – Gym Ball activities

All these exercises were visually demonstrated and verbally instructed to the subjects by the trainers. The intensity level of the exercises was progressed based on the CST protocol guidelines. Details on attendance for each session, any injury or hospitalization of Training group subjects were maintained in a Training Log Sheet. The participants in Control Group were asked to carry out their usual activities without any training. Usual activities of college students were not restricted during the study period due to ethical reasons, however, the control group subjects were also given 'Participant Log Sheet', and asked to note down about how many sports session they involved and whether there was any injury or hospitalization during the study period to consider the interaction of these factors while interpreting the study results later.

Post-Intervention phase: At the end of 8th week, all the participants have undergone post-intervention measurement to find out their level of dynamic balance and sports functional performance using the same set of tests that were used during pre-intervention data collection. The log sheet information of both groups was also collected to consider them while interpreting the outcome of the study so as to minimize the effect of co-intervention factors if any. All the training and measurement sessions were conducted in MAHSA University's Physiotherapy Gymnasium and play area.

Data Analysis

Data was neatly tabulated on master chart and SPSS software version 22.0 was used to analyse the data. Both descriptive and inferential statistics were used. Inter and intra group comparisons were done by using Mann Whitney U test and Wilcoxon Signed Rank test respectively. To see the impact of confounding factors such as age, race, BMI on training effects in Training Group, Repeated Measures 2-Way ANOVA was used.

RESULTS

Comparative study on the effect of core stability training on the sports functional performance and dynamic balance has showed that core stability training has a significant effect on sports functional performances such as T- agility running (p=0.022), 40-Yard running (p=0.006), vertical jump (p=0.030), except, medicine ball throw (p=0.348) on subjects of training group immediately after 8 weeks of core stability training compared to Control Group. The study has also showed that there was an improvement noticed on dynamic balance (p=0.200), however it was not statistically significant between TG and CG.

In regard to within group analysis, both Control Group and Training Group have showed improvement in all the sports functional performances, however the difference were found to be more significant in the Training Group subjects in all sports functional performances; T- agility running (p=0.000), 40-Yard running (p=0.000), vertical

jump (p=0.000), medicine ball throw (p=0.033). In regard to the dynamic balance, there was no significant difference noted both in Control Group (p=0.900) and Training Group (p=2.00), however Training Group subjects have showed better improvements compared to Control Group subjects.

		Control Group	Training Group	*p* - Value
T – Test - in Sec.	Pre-Intervention	13.22	13.54	0.686
	Post-Intervention	12.97	11.57	0.022*
	p - Value	0.025*	0.000*	
40-Yard Test - in Sec.	Pre-Intervention	16.64	16.20	0.648
	Post-Intervention	16.14	13.90	0.006*
	p - Value	0.003*	0.000*	
Medicine Ball Throw - Distance in meter	Pre-Intervention	5.51	5.54	0.611
	Post-Intervention	5.92	5.98	0.348
	p - Value	0.006*	0.033*	
Vertical Jump - Height in inches	Pre-Intervention	16.38	16.83	0.620
	Post-Intervention	16.89	19.08	0.030*
	p - Value	0.283	0.000*	

*Indicates statistically significant difference ($p<0.05$)

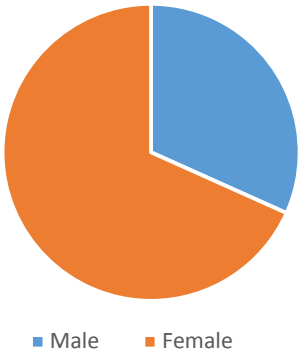
Table 1: Mean values of Pre & Post-Intervention Sports Functional Performances Among Control Group And Training Group - Between and Within Group Analysis

		Control Group	Training Group	*p* - Value
Dynamic Balance – Right Upper Quarter NC Reach Distance in YBT Scale	Pre-Intervention	88.57	88.40	0.886
	Post-Intervention	88.71	90.55	0.620
	p - Value	0.679	0.444	
Dynamic Balance – Left Upper Quarter NC Reach Distance in YBT Scale	Pre-Intervention	88.38	87.75	0.667
	Post-Intervention	89.09	89.75	0.620
	p - Value	0.970	0.586	
Dynamic Balance – Right Lower Quarter NC Reach Distance in YBT Scale	Pre-Intervention	101.19	101.25	0.948
	Post-Intervention	100.85	102.70	0.794
	p - Value	0.640	0.545	
Dynamic Balance – Left Lower Quarter NC Reach Distance in YBT Scale	Pre-Intervention	102.10	101.60	0.565
	Post-Intervention	102.14	103.80	0.666
	p - Value	0.955	0.333	
Dynamic Balance – Total NC Reach Distance in YBT Scale	Pre-Intervention	380.24	379.00	0.876
	Post-Intervention	380.81	386.80	0.639
	p - Value	0.900	0.200	

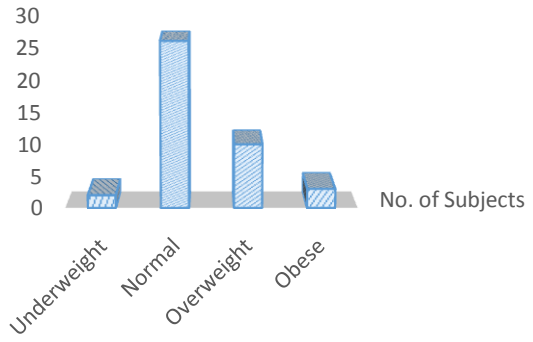
Indicates statistically significant difference ($p<0.05$)

NC Reach Distance – Normative Composite Reach Distance in YBT Unit scale

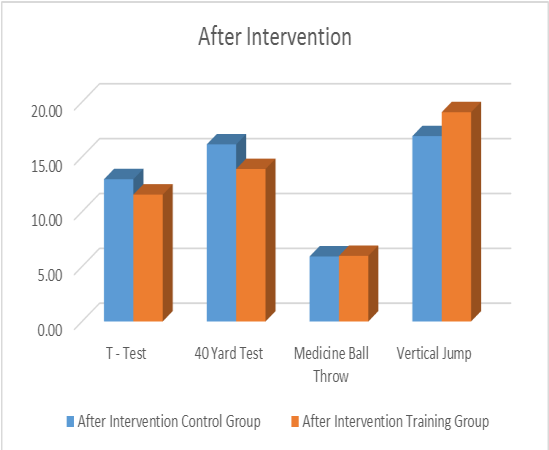
Table 2: Mean values of Pre & Post-Intervention Dynamic Balance (YBT Measure) Among Control Group And Training Group -Between and Within Group Analysis



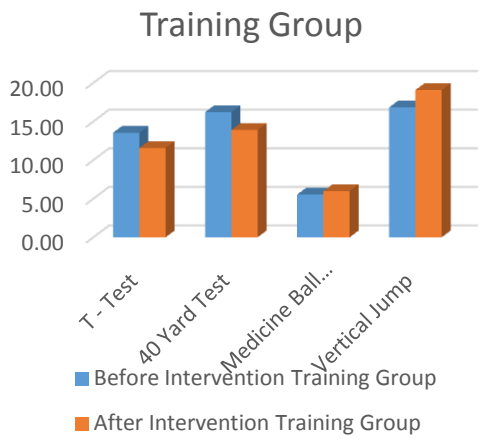
Graph 1: Gender distribution of the subjects studied



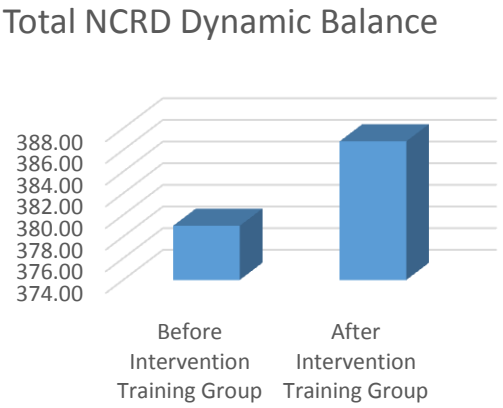
Graph 2:BMI Category distribution of subjects studied



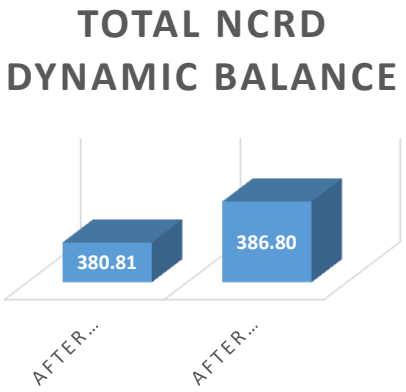
Graph 3: Post-Intervention analysis between CG and TG (Sports Functional Performances)



Graph 4: Post-Intervention analysis between CG and TG (Dynamic Balance)



Graph 5: Post-Intervention analysis within TG



(Sports Functional Performances)

Graph 6: Post-Intervention analysis within TG (Dynamic Balance)

DISCUSSION

A total of 41 subjects (males 13, females 28) in both Training and Control group with the mean age of 19.10 had sustained the whole research process and available for post-intervention data collection out of 50 subjects selected at the beginning. In the training group 5 subjects have lost their follow up whereas in the control group 4 subjects have dropped out due to non-medical reasons. The following BMI categories were identified among the study subjects, Underweight 2 (5%), Normal BMI 26 (63%), Overweight 10 (24%), and Obese 3 (7%) at the beginning of the study.

The primary purpose of this double-blinded, single-centred RCT study was to see the effect of core stability training on sports functional performances and dynamic balance on healthy undergraduate university students who were randomized into either core stability Training Group with Dublin Core Stability Active training protocol or Control Group. The base line values for Sports Functional Performances and Dynamic Balance of TG and CG were found to be equal with no significant difference, shows the subjects were quiet similar before the start of the intervention. We hypothesized that greater improvements will be achieved in the Training Group subjects after the 8-week core stability training programme on core stability level as well as in all sports functional performances compared to Control Group. In favour of this hypothesis, subjects who underwent the Dublin Core Stability Active training protocol showed better improvement in their dynamic balance, which was measured through the YBT Functional Goniometer Normative Composite Reach Distance for all limbs /quadrants, but this was not statistically significant, however there has been a clear transformation of the training effect was found on most of the sports functional performances such as T-agility running, 40-Yard Distance running and Vertical jump, except the medicine ball throw activity. Hence, this study confirms the cause and effect relationship between core stability training and sports functional performances for all the lower limb related activities among healthy college level students, in favor to the work of Sharrock et al (2011) and Stanton et al(2004), who concluded that there is a significant relationship between the core stability training and sports performance on athletes and runners respectively [5, 8]. The results of the current study is found to be in line with the work of Okada (2011) in respect to the upper limb functional performance, who concluded that there is no correlation between backward medicine ball throw with core stability in healthy individuals[21].

The improvements were found to be better in the lower limb performances such as T-run (agility running) 40-Yard running, Vertical jump compared to upper limb performances (Medicine ball throwing). This could be possibly due to large quantity of lower limb related workouts in the 'Dublin Core Stability Protocol' used for core stability training both at Mat and Swiss Ball exercises. This can be confirmed by the significantly increased score of core stability measures for Lower Quarter than Upper Quarter of YBT among the subjects of training group. This supports notion that core stability training methods need to be more specific to the type of sports performance intended[1].

Within Control and Training Group have showed improvement before and after the intervention on agility running, 40 yard running, medicine ball throw, except vertical jump and the difference was found to be better in Training Group subjects in all sports functional performances significantly, however in the dynamic balance level, there is no statistically significant difference was found though the Training Group subjects have showed better results compared to Control Group subjects. This raises questions on the effect of training given could be due to possible interaction of some confounding factors related to training programme. Since the usual play activity of university students both in the Training Group and Control Group were not controlled due to ethical reasons, the possible interaction of any co-intervention was analysed from the filled-in Log-Sheets obtained from both the group and

found there was no significant difference among both groups in regard to number of hours played and nobody were injured or hospitalized during the training period. During the training programme there has been 5 drop outs from the Training Group and 4 drop outs from Control Group were recorded; however the reasons for drop out were obtained later to be non-medical in all the dropped out subjects. Moreover, this cannot affect the sample power size since the required sample size was determined to be only 40 and in anticipation of high attrition rate, additionally 10 samples were recruited in this study at the beginning. In regard to attendance of the subjects, in the Training Group a total number of 20 students underwent training and attended a total number of 24 sessions (3 sessions per week for 8 weeks). 83% of attendance was attained. The attendance percentage for each session was ranging as low as 60% to as high as 100%. The marked lack of attendance in few of the sessions can be attributed for the loss of statistical significance in the effect among the Training Group before and after intervention.

In regard to the interaction of demographic factors, male subjects scored higher on the sports functional performances and core stability when compared to female subjects overall, this is consistent with study done by Leetun et al (2004), this could be possibly due to males have greater advantage in the bone structure and postural differences in the pelvis from females in regard to lower limb athletic activities[6]. Better sports performance and dynamic balance were noted among the normal BMI subjects confirms that there is definitive relationship between sports performance with ideal height and weight measurements of an individual, which stresses the need for an ideal anthropometrics to excel in the sports functional performance, suggests on the importance of weight control exercise in the sports training protocol specific to the particular sport[25].

In regard to the qualitative information obtained from both group subjects such as Level of awareness on core stability, Improvement in the state of body posture, Level of ease felt while doing ADLs, these were quantified and analysed, which supports the fact that 8 weeks of core stability training can also enhance the subjects' cognitive awareness on core muscles and sense of ease while carrying out ADLs. Similar effects on cognitive aspects were noted in the study of SethiVanshika (2012), who concluded that this could be possibly due to association of physical exercises that increases self-image, which in turn result in increased self-esteem[22].

Measuring core stability is a difficult task with no test or measure serving as a gold standard. Core stability is a broad construct that includes proprioceptive control, strength, power and endurance, hence the outcome measure need to reflect all these components.Dynamic balance, which measured through YBT Functional Goniometer, was theoretically believed to be more appropriate since it is dynamic, which mimics complex, explosive, multi-planar movements[20]. Though there were some improvements found on the YBT Reach scores, its clinical significance was not clearly brought out with the core stability training. Hence, it is recommended to carry out further studies using YBT as an outcome measure to determine its clinical validity and reliability in regard to core stability training programmes on dynamic balance.

CONCLUSION

The outcome of the research adds a meaningful explanation to the impact of core stability training on sports related functional activities and dynamic balance among healthy undergraduate college level population. An understanding of this causal relationship clinically supports the inclusion of core stability trainings for healthy amateur college level sports population and can be considered while developing sports training protocol and guidelines by the sports physiotherapists, strength & conditioning specialists, team coaches and physical educators. This research can be a further extended to be a

multicentre trial in specific to different amateur sports population in different age group.

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