ORIGINAL RESEARCH

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EFFECT OF CORE STABILITY TRAINING ON DYNAMIC BALANCE IN HEALTHY YOUNG ADULTS - A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Background: Balance is a key component of normal daily activities. Therefore, it is necessary to find various programs to improve balance. The core functions to maintain postural alignment and balance during functional activities. The purpose was to study the effects of the core stability training on dynamic balance in healthy, young adults.

Methods: It was an interventional study, in which 60 healthy young adults were selected. They were randomly divided into two groups of 30 each, one being experimental group and other control group. Measurement of their height, weight, BMI and leg length was taken. Subjects in both the groups were assessed for core stability with pressure biofeedback unit (PBU) and dynamic balance using Star Excursion Balance Test (SEBT) pre and post intervention. Subjects in the experimental group underwent progressive core stability training program for six weeks (3days/week) and control group was refrained from any type of structured training program.

Results: There was statistically significant improvement in core stability and dynamic balance of the experimental group after six weeks of intervention.

Conclusion: It is concluded that core stability training of six weeks duration is effective in improving dynamic balance in healthy, young adults.

Key words: core stability, dynamic balance, star excursion balance test, pressure biofeedback unit.

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INTRODUCTION

The human core is important because it is the anatomical location in the body where centre of gravity is located, thus where movement stems.[1]

Bergmark[2] categorized the trunk muscles into local and global stabilizers based on their main mechanical principles. Local stabilizing system includes deep muscles or deep portions of some muscles which have their origin or insertion on the lumbar vertebrae. The local muscles are capable of controlling the stiffness and intervertebral relationship of the spinal segments and the posture of the lumbar spine. The global muscles are not only responsible for transferring load between the thoracic cage and the pelvis but also to balance the external loads applied to the trunk so that the residual forces transferred to the lumbar spine can be handled by the local muscles. In this way, the large variations in external loads that occur with normal daily functions are accommodated by the global muscles so that the resulting load on the lumbar spine and its segments is continually minimized.

Balance is a key component of normal daily activities such as walking, running and climbing stairs. It can be defined as the "ability to maintain the body's center of gravity within the limits of stability as determined by the base of support."[3] Due to the complexity of balance, controlling it involves interaction of neurologic, musculoskeletal, proprioceptive, vestibular and visual system. Nasher[4] concludes that balance is achieved through a compilation of sensory, motor and biomechanical process. As balance and joint stability mutually depend on sensory input from peripheral receptors, balance can be interpreted as a function of joint stability. Dynamic balance is a very important aspect of everyday life. Hence, it is imperative to find programs useful for measuring, maintaining and improving balance for injury prevention and rehabilitation.

Logically, strengthening core muscles will improve stability of the lumbar spine. What has been researched in much less detail is the effect that core stability training will have on tasks that encompass whole body movement and dynamic postural control.[5] Therefore, the main purpose of this study is to verify the effects of the core stability training on dynamic balance in healthy young adults.

MATERIALS AND METHODS

Ethical clearance was obtained from institutional ethical committee as per guidelines for Bio-medical Research on human subjects. Participants were recruited from tertiary health care centre after obtaining consent from the hospital and participants. Young non-exercising females of 18-25 years of age with height of 150-170cms and normal BMI were included. Subjects with any musculoskeletal injuries, neurological and vestibular conditions, LBP in last 6 months were excluded. Total 60 subjects (n = 60) were randomly allocated to two groups i.e. experimental group and control group using the closed chit method. Subjects were divided into both the group of 30 each. All the subjects had to give details regarding demographic data which included name, age, sex, address and occupation. Pre-training session was held for both groups in which body mass index (BMI), limb length, core stability and dynamic balance was assessed.

BMI was calculated using the formula, BMI = WEIGHT IN KG/(HEIGHT IN MTS).In supine, after squaring the pelvis, limb length was measured from the antero-superior iliac spine to the middle of the medial malleolus using a standard tape measure. The limb length measure was used to normalize reach distance data (excursion ÷ leg length × 100). Core stability was assessed using pressure biofeedback unit[6] (figure 12) and dynamic balance was assessed by the Star Excursion Balance Test[7,8] (figure 13, figure 14). The subjects in the experimental group then underwent progressive core stability training program for six weeks (table 1) and the control group refrained from any form of structured core stability training for six weeks but continued with all other daily activities. The core stability program included crook lying with abdominal hollowing (figure 1), kneeling with abdominal hollowing (figure 2), quadruped with one leg raise and abdominal hollowing (figure 3), quadrepud with opposite leg and arm raise and abdominal hollowing (figure 4), kneel sitting to kneeling with abdominal hollowing (figure 5), squatting with abdominal hollowing (figure 6), ball sitting with one leg raise and abdominal hollowing(figure 7), roll ball in and out with abdominal hollowing (figure 8), standing on skates with abdominal hollowing (figure 9), air cycling with abdominal hollowing (figure 10), side plank (figure 11) After six weeks, both groups underwent post-training session where core stability and dynamic balance was assessed again.

Figure1: Crook lying with abdominal hollowing

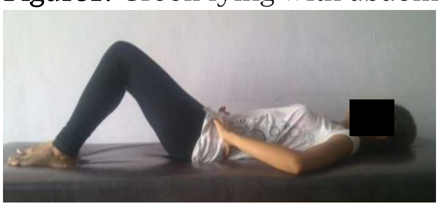


Figure 2: kneeling with abdominal hollowing

Figure 3: quadruped with one leg raise and abdominal hollowing

Figure 4: quadripud with opposite leg and arm raise and abdominal hollowing

Figure 5: kneel sitting to kneeling with abdominal hollowing

Figure 6: squatting with abdominal hollowing

Figure 7: ball sitting with one leg raise and abdominal hollowing

Figure 8: roll ball in and out with abdominal hollowing

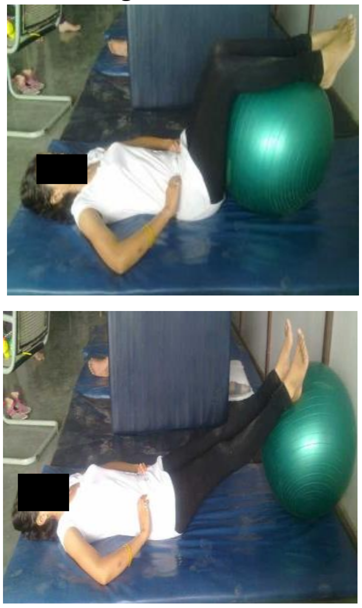


Figure 9: standing on skates with abdominal hollowing

Figure 10: air cycling with abdominal hollowing

Figure 11: side plank

Figure 12: pressure biofeedback unit

Figure 13: star excursion balance test

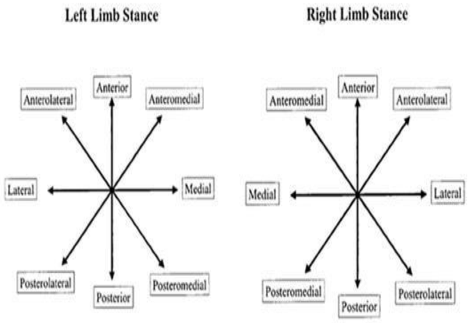


Figure 14: star excursion balance test

TABLE 1: CORE STABILITY TRAINING PROGRAME

Week(sec*time) / exs ⇩	1	2	3	4	5	6
1	5secsx5	10secsx5	15secsx10	20secsx10	25secsx15	30secsx15
2	5secsx5	10secsx5	15secsx10	20secsx10	25secsx15	30secsx15
3	5secsx5	10secsx5	15secsx10	20secsx10	25secsx15	30secsx10
4	5secsx5	10secsx5	15secsx10	20secsx10	25secsx15	30secsx10
5	5secsx3	10secsx3	10secsx5	15secsx10	20secsx10	25secsx15
6	5secsx3	10secsx3	10secsx5	15secsx10	20secsx10	25secsx15
7	5secsx3	10secsx3	10secsx5	15secsx10	20secsx10	25secsx15
8	3secsx3	5secsx5	10secsx5	10secsx10	15secsx10	15secsx15
9	3secsx3	5secsx5	10secsx5	10secsx10	15secsx10	15secsx15
10	3secsx3	5secsx5	10secsx5	10secsx10	15secsx10	15secsx15
11	3secsx3	5secsx5	10secsx5	10secsx10	15secsx10	15secsx15

DATA ANALYSIS

The data was entered using MS-EXCEL-2007 and analyzed using Statistical Package for Social Sciences (SPSS-16) software. The data was numerical and normally distributed. Paired t-test was used for the comparison of mean within the two groups. Unpaired t-test was used for the comparison of mean between the two groups. P-value less than 0.05 were considered as significant.

TABLE 2: PRE INTERVENTIONAL COMPARISIONS

Group (mean ± SD)	Exp. group	Control group	P value
Age in years	18.7 ± 1.6	19.1 ± 1.4	0.399
BMI	21.5 ± 1.8	20.9 ± 1.7	0.245
LEFT L/L	84.1 ± 4.2	83.7 ± 3.8	0.678
RIGHT L/L	84.1 ± 4.2	83.7 ± 3.8	0.678
PRE CORE	6.03 ± 1.8	6.3 ± 3.1	0.689
PRE LA	97.4 ± 8.3	96.7 ± 11.6	0.796
PRE LAM	101.5 ± 11.2	101 ± 13.2	0.857
PRE LM	94.6 ± 8.5	93.4 ± 13.7	0.700
PRE LPM	93.6 ± 10.2	91.1 ± 12.1	0.395
PRE LP	85.8 ± 12.6	84.4 ± 11.2	0.663
PRE LPL	78.8 ± 9.1	81.2 ± 9.2	0.312
PRE LL	71.07 ± 10.3	74.07 ± 10	0.260
PRE LAL	92.8 ± 9.4	92.4 ± 12	0.878
PRE RA	95.8 ± 8.9	96.07 ± 13	0.950
PRE RAM	99.2 ± 10.1	98.07 ± 15.3	0.724
PRE RM	92.5 ± 10.9	90.3 ± 16.4	0.539
PRE RPM	88.3 ± 9.2	86.1 ± 14.1	0.495
PRE RP	77.9 ± 8.5	80.2 ± 12.07	0.393
PRE RPL	76.5 ± 7.5	79.1 ± 10.1	0.275
PRE RL	66.8 ± 12.8	71.5 ± 11.8	0.149
PRE RAL	93.4 ± 8.6	94.7 ± 12.8	0.660

Table 2 shows that basic characteristics of subject between control and experimental group showed no significant difference. The pre-intervention core stability and excursion distances in between the groups were non-significant.

Graph 1 shows that there is no statistically significant difference ($p = 0.161$) when pre intervention means were compared between experimental group (6.03 ± 1.8) and control group (6.3 ± 3.1). There is statistically significant difference ($p < 0.001$) when post intervention core stability means were compared between experimental group (8.7 ± 1.6) and control group (6.03 ± 2.6).

Graph1: Comparison of core stability in two groups

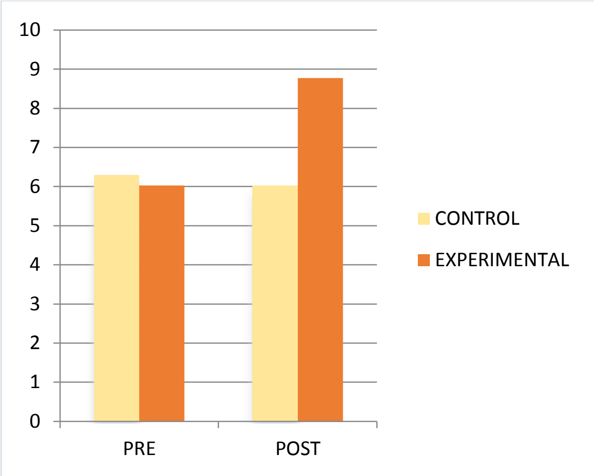
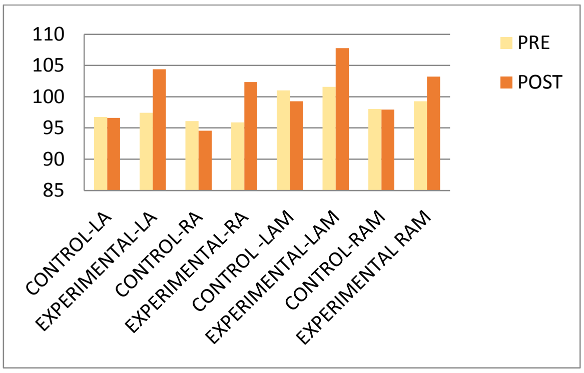


Table 3 shows that there is no statistically significant difference in the control group when pre and post interventional excursion distances of LA (left anterior), RA (right anterior), RAM (right antero-medial), LM (left medial), RM (right medial), LPM (left postero medial), RPM (right postero medial), LP (left posterior), RP (right posterior), LL (left lateral), RL (right lateral), LAL (left antero-lateral), RAL (right antero-lateral) were measured. There is statistically significant difference in the control group when pre and post interventional excursion distances of LAM (left antero-medial), LPL (left postero- lateral) and RPL (right postero-lateral) were measured. There is statistically significant difference in the experimental group when pre and post interventional all excursion distances are compared. Graph 2, graph 3, graph 4 and graph 5 shows the comparison of excursion distances between the groups.

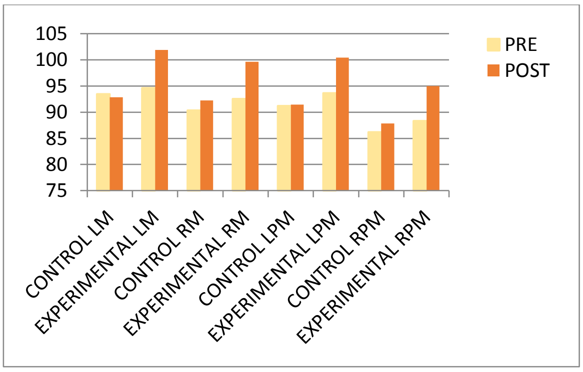
TABLE 3: COMPARISON OF EXCURSION DISTANCES IN BOTH GROUPS

EXCURSION DISTANCES (MEAN ± SD)	EXPERIMENTAL GROUP			CONTROL GROUP		
	PRE	POST	P VALUE	PRE	POST	P VALUE
LA	97.4 ± 8.3	104.3 ± 8.1	< 0.001	96.7 ± 11.6	96.6 ± 11.3	0.826
RA	95.8 ± 8.9	102.3 ± 8.7	< 0.001	96.07 ± 13.2	94.5 ± 13.6	0.130
LAM	101.5 ± 11.2	107.7 ± 11.2	< 0.001	101 ± 13.2	99.2 ± 12.6	0.016
RAM	99.2 ± 10.1	103.2 ± 15.2	< 0.001	98.07 ± 15.3	97.9 ± 15.5	0.826
LM	94.6 ± 8.5	101.9 ± 9.04	< 0.001	93.4 ± 13.7	92.8 ± 12.8	0.509
RM	92.5 ± 10.9	99.6 ± 10.9	< 0.001	90.3 ± 16.4	92.2 ± 14.2	0.320
LPM	93.6 ± 10.2	100.4 ± 10.4	< 0.001	91.1 ± 12.1	91.4 ± 12.1	0.761
RPM	88.3 ± 9.2	95 ± 9.22	< 0.001	86.1 ± 14.11	87.8 ± 12.8	0.127
LP	85.8 ± 12.6	92.6 ± 12.8	< 0.001	84.46 ± 11.2	84.03 ± 11.5	0.465
RP	77.9 ± 8.5	85.5 ± 9.22	< 0.001	80.2 ± 12.07	80 ± 11.03	0.731
LPL	78.8 ± 9.1	85.1 ± 10.2	< 0.001	81.2 ± 9.2	80.08 ± 8.9	0.033
RPL	76.5 ± 9.3	80.12 ± 9.7	< 0.001	79.13 ± 10.1	77.7 ± 10.1	0.043
LL	71.07 ± 10.3	78.7 ± 10.2	< 0.001	74.07 ± 10.03	73.3 ± 11.5	0.394
RL	66.8 ± 12.8	73.2 ± 12.5	< 0.001	71.5 ± 11.8	69.08 ± 11.7	0.168
LAL	92.8 ± 9.4	98.9 ± 9.4	< 0.001	92.4 ± 12.08	92 ± 12.5	0.694
RAL	93.4 ± 8.6	99.4 ± 8.6	< 0.001	94.7 ± 12.8	93.4 ± 12.6	0.157

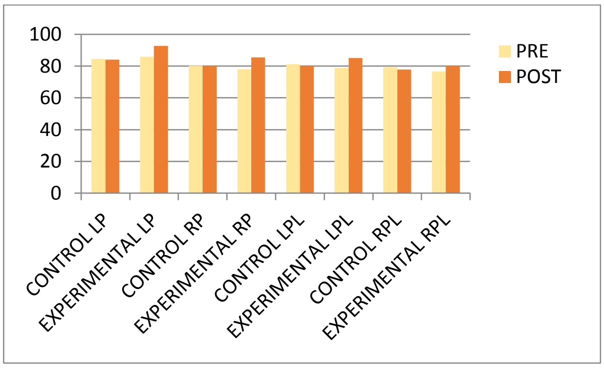
GRAPH 2: comparison of excursion distances (LA, RA, LAM, RAM) in both the groups.



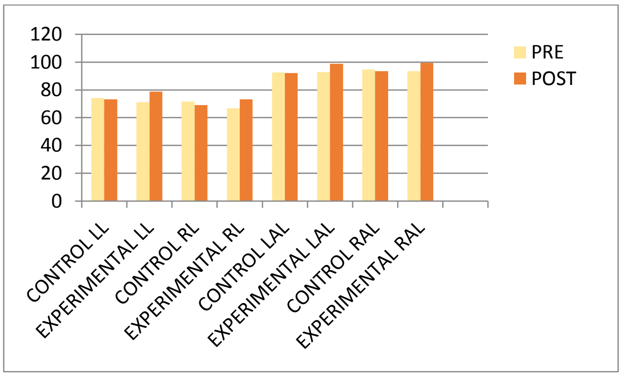
GRAPH 3: comparison of excursion distances (LM, RM, LPM, RPM) in both the groups



GRAPH 4: comparison of excursion distances (LP, RP, LPL, RPL) in both the groups



GRAPH5: comparison of excursion distances (LL, RL, LAL, RAL) in both the groups



DISCUSSION

The results of the present study revealed that there was significant improvement in core stability and dynamic balance in experimental group following core stability training program. For all the directions, normalized maximum excursion distances increased significantly in the experimental group. This improvement in reach distance verifies the positive effect of core stability training on dynamic balance.

The core comprises the lumbo-pelvic –hip complex as most of the prime mover muscles for the distal segments (latissimus dorsi, pectoralis major, hamstring, quadriceps and iliopsoas) and major stabilizing muscle for the extremities(upper and lower trapezius, hip rotators and glutei) attach to the core. The abdominal muscles consist of the transversus abdominus, internal and external oblique and rectus abdominis. Abdominal muscle contractions help create a rigid cylinder, enhancing stiffness of the lumbar spine.[9] The transversus abdominis has been shown to be critical in stabilization of the lumbar spine.[10,11] The rectus abdominis and oblique abdominals are activated in direction specific patterns with respect to limb movements, thus providing postural support before limb movements.[12,13]

According to Kibler[14], the core acts as an anatomical base for motion of the distal segments and its governing musculature works synergistically to produce and reduce force and provide dynamic stabilization throughout the kinetic chain. The body uses core muscle activation to generate the necessary rotational torque around the body and produce extremity motion. So, in the SEBT, as the subject stands on the stance leg and uses the opposite limb to reach, the rectus abdominis and obliques would fire before the movement occurs to perform trunk motion, allowing the subject to maintain balance while the multifidus and transversus abdominus muscles would help to maintain dynamic balance during lower extremity movement by providing support to the lumbar spine.[14]

Hodges and Richardson identified trunk muscle activity before activity of the lower extremity, which helps the spine to stiffen leading to a foundation for functional movements. They also found that the transversus abdominus is the first muscle to become active prior to actual limb movement and this preprogramed activation of the transversus abdominus was a component of the strategy used by the CNS to control spinal stability. Richardson proposed that a precise co-contraction of the transversus abdominus and multifidus are independent of the global musculature, neutral spine posture and low-level continuous tonic contractions. This feed forward nature of activation increases muscle stiffness and segmental stabilization to provide more efficient use of the primary muscles.[15]

Bouisset[16] proposed that stability of the pelvis and trunk is necessary for all movements of the extremities and hence proximal stability is necessary in order to prevent lower extremity injury. The quality of the actions during functional movements require optimum neuromuscular efficiency and control. Mechanoreceptors provide the central nervous system (CNS) with appropriate proprioception feedback to maintain normal length-tension relationships and force-couple relationships through a circling effect of passive(spinal column) to control(neural) to active(muscular)systems in order to maintain this efficient state(inner core activated prior to outer core musculature). This in turn leads to optimal arthrokinematics in the lumbo-pelvic hip complex during functional kinetic chain movements, optimal neuromuscular efficiency in the entire kinetic chain, optimal acceleration,deceleration, dynamic stabilization of entire kinetic chain during functional movements and provides proximal stability for efficient lower extremity movements.

There is no universally accepted standard programme for core stabilization with respect to type, frequency and duration of the prescribed exercises.[17] Kimberely[18] found a difference on dynamic balance at five weeks; hence we undertook a six week training programme as was also followed by Nichole Kahle. The exercises for a core stability training programme need to concentrate on motor control, emphasizing the neutral spine posture and contraction of the pelvic floor muscles and transversus abdominis with the multifidus.[18] The exercises included in this study progressed from large to small base of support and from stable to unstable surface. It included movements required for dynamic balance and added the core stabilization element to it.

Factors such as height and limb length affect excursion distance and hence in our study we used participants with matched leg length in both groups. Also normalization of leg length for all participants was performed for more accurate comparison amongst subjects. According to Gribble's[19] study foot type, hip ROM measurements at hip (internal and external rotation) and ankle dorsiflexion was not related to performance in SEBT and hence not considered during the study.

LIMITATIONS

Small sample size. The order of trials was not randomized. The core training was not tailor-made to meet individual's requirement. Long term follow up was not studied.

CLINICAL IMPLICATIONS AND APPLICATIONS

Core stability training can be used in patients with balance deficits, so as to improve balance and reduce risk of fall and injuries, thus leading to a better quality of life. Individuals of all the age groups undergoing fitness regime should include core stability exercises. In athletes and players, core stability training can be incorporated to improve performance and minimize injuries.

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