JOURNAL OF COMPLEMENTARY MEDICINE RESEARCH
Journal of Complementary Medicine Research, ISSN: 2146-8397 Vol. 14, No. 2, 2023 (pp.110-116)
RESEARCH ARTICLE
WWW.JOCMR.COM

Effect of Biodex Balance Training on Postural Stability in Patients with Primary Dysmenorrhea

Mohamed Salem[1,2*], Shamekh El-Shamy[1,2], Ali Hussein, Anwar Ebid[1,2], Amal Alharbi[1], Khadijah Alhindi[1], Raghad Alqurashi[1], Rahaf Fatani[1], Sarah Hijji[1], Sarah Alzahrani[1]

[1]*Department of Physical Therapy, College of Applied Medical Sciences, Umm Al Qura University, Makkah, Kingdom of Saudi Arabia (KSA)*

[2]*Faculty of physical therapy, Cairo University, Giza, Egypt*

ABSTRACT

Background: Dysmenorrhea is one of the most common causes of pelvic pain in women, estimates of the prevalence of dysmenorrhea range widely from 16.8 % to 81%, with high rates as 90% have been recorded. It has a negative impact on the quality of life of affected females, leading to activity restrictions. Pelvic stability decreases in women with dysmenorrhea, leading to lumbar pelvic imbalance, resulting in impaired balance control. **Purpose:** The purpose of this study was to determine the effect of Biodex balance (BBS) training on pain, postural stability and functional activities during dysmenorrhea. **Methods:** Thirty participants suffering from primary dysmenorrhea with a regular menstrual cycle were randomly assigned to experimental group (n=15) and control group (n=15). The experimental group received sessions in BBS training combined with traditional core stability exercises while the control group received only traditional core stability exercises for 4 weeks (three sessions per week). The BBS was used to assess postural stability and limit of stability, while the Visual analog scale (VAS) was used to assess pain intensity and Patient specific functional scale (PSFS) to assess the ability to perform activities. All measurements were obtained before, during the menstrual cycle, and after receiving the treatment. **Results:** The mean values of all variables showed no significant difference in the pre, mid menstrual cycle an d post-treatment assessments, p values were insignificant ($P>0.05$) between the 2 groups except for post-post treatment assessment for limit of stability ($p<0.05$). However, both groups showed improvement in all variables when comparing pre and post balance assessments. **Conclusion:** Balance training with BBS has a positive effect on dysmenorrhea patients by improving postural stability, functional activities, and decreasing pain intensity

Corresponding Author e-mail: egy.doc2020@yahoo.com.sa

How to cite this article: Salem M, El-Shamy S, Hussein A, Ebid A, Alharbi A, Alhind K, Alqurashi R, Fatani R, Hijji S, Alzahrani S. (2023) Effect of Biodex Balance Training on Postural Stability in Patients with Primary Dysmenorrhea Journal of Complementary Medicine Research, Vol. 14, No. 2, 2023 (pp. 110-116).

INTRODUCTION

Dysmenorrhea is one of the most well-known reasons for pelvic agony in females, evaluations of the predominance of dysmenorrhea range broadly from 16.8 % to 81%, with high rates as 90% have been recorded [1]. Menstrual cycle, which lasts from menarche to menopause, is transient uterine bleeding. It is dependent on endometrial disintegration and exfoliation, which usually takes place in a regular cycle lasting between 21 and 45 days, with blood flow lasting between 2 and 6 days and an average blood loss of between 20 and 60 mL [2].

The significant symptoms of dysmenorrhea are pelvic or lower stomach torment, queasiness, loose bowels, and back torment. These side effects ordinarily start at the hour of period and stay in 3 days or less [3].

Dysmenorrhea negatively affects the quality of life and may lead to activity restrictions like school and work absenteeism, as well as limitations on social and recreational activities, academic and professional performance [2,3]. Approximately 15% of women with dysmenorrhea are affected by symptoms severe enough to cause absenteeism from work, school, and other activities, even for women who don't miss school or work over menstrual-related symptoms, the reduced productivity associated with those symptoms negatively affects performance.[4-6]

Pelvic stability may decrease in women with dysmenorrhea, leading to lumbar pelvic imbalance, which can lead to improper proprioception input into the central nervous system, resulting in impaired balance control.[7,8] Biodex balance system (BBS) is a multi-axis advanced device that provides objectively accurate and dependable data about a person's balance and capacity to stabilize a joint under dynamic stress so it can be utilized for testing and treatment.[9,10]

KEYWORDS:
Dysmenorrhea, Biodex Balance System, Exercises, Postural Stability, Pain, Functional Activities .

ARTICLE HISTORY:
Received : Dec 25, 2022
Accepted : Jan 18, 2023
Published: Feb 21, 2023

DOI:
10.5455/jcmr.2023.14.02.17

Several studies have been directed on the impact of the menstrual cycle on postural stability, Sung and Kim [11] explained that postural stability during the menstrual cycle is negatively correlated with estrogen. Another study used side hop test (SHT), figure of eight hop test (F8T), and modified star excursion balance test (mSEBT) to evaluate the functional performance of 13 healthy women, the study revealed that different menstrual cycle phases had an impact on healthy and young women's functional performance [12,13]. The levels of the sex hormones estrogen and progesterone in the body during the menstrual cycle (MC) are highly dependent on the time of year. The levels of these hormones peak at the start of the MC, peaking at the end of the luteal phase and then again in the luteal phase1 (LP). According to studies, these sex hormones have the potential to modify sensory perception and motor responses by acting on membrane receptors [1,2,3] and influencing neurotransmitters including GABA, serotonin, and glutamate, Additionally, we propose that estrogen and progesterone affect physiological processes as anaerobic and aerobic capacity, alterations in soft tissues, postural control, muscular strength, proprioception, and neuromuscular coordination by reducing fibroblastic activity, estrogen also has biological effects that reduce collagen formation in tendons.[12]

Lee et al.[13] studied the effect of the menstrual cycle on the static balance of healthy women and found that postural sway tended to increase approximately 13 days following menstruation, The research showed how the menstrual phase adversely affects the static balance of healthy women. Some authors have also focused on menstrual pain and its effect on general wellbeing, based on findings, menstrual pain is highly prevalent and poorly managed[14]. So, the purpose of this study was to determine the effect of Biodex balance training on postural stability, pain, and functional activities in patients with dysmenorrhea.

MATERIALS AND METHODS

Study design

A randomized clinical trial study design. The study was approved by the biomedical research Ethics Committee at Umm Al-Qura University, approval no (HAPO-02-K-012-2022-02-947). Before signing an informed consent form accepting to participate in the study, all subjects were given a full explanation of the study's procedures, objectives, and hazards. This study was carried out from February 2022 to June 2022.

Participants

A total of sixty Saudi female students from Umm Al-Qura University were included in this study, forty-three of them completed the initial assessments, thirteen participants of the forty-three withdrew due to private reasons, and didn't complete the treatment program, so the study started with thirty participants. The inclusion criteria were Saudi female students (Umm Al-Qura University) suffering from dysmenorrhea with a regular menstrual cycle (average is to have periods every 28 days), ages ranging between 18-25 years. The exclusion criteria were Irregular menstrual cycle (anything outside the range 21-35 considered a regular), age less than 18 years or more than 25 years, history of cardiovascular disease, neuromuscular disorders, taking any medication that would affect sex hormones or balance, pregnant women, and coronavirus (COVID -19) cases.

Randomization

The patients were randomly assigned to control group (n=15) and experimental group (n=15) by putting even numbers on excel sheets into the experimental group and odd numbers into the control group to prevent bias in the treatment assignment (Fig. 1).

Assessment

The assessment was conducted in Physiotherapy department at Umm Al-Qura University, we recorded the subject's name, age, height, weight, and calculated body mass index (BMI). Thirty participants have done the assessment three times, before, during the menstrual cycle, and after receiving the treatment.

Biodex Balance System (BBS) (Biodex Medical System, Shirley, NY, USA) has been used to evaluate posturalstability and limit of stability. This system is versatile, allowing it to be used to assess balance [15], determine proprioceptive and kinesthetic abilities, and determine neuromuscular control (stability and degree of sway values). The current study used an available balance device in the physiotherapy labs, which is a valid and reliable tool to assess the balance. The BBS (version biodex SW PN 950-440-E617) simulates movements in the anterior-posterior and medial-lateral directions, and a 360° mobile circular platform with a 20° tilt, support rails [16] (Fig. 2).

Pain assessment

Visual analogue scale has been used to evaluate participants' amount of pain, VAS is a unidimensional measure of pain intensity, the scale is anchored by (score of 0) which indicates no pain, and (score of 10) which indicates the worst possible pain.The pain (VAS) is self-completed by the subjects which were asked to make a mark on the VAS line at the point that represents their pain intensity [17]. VAS scores have been taken firstly before the menstrual cycle, secondly during the menstrual cycle, and lastly after the treatment intervention.

Functional activities assessment

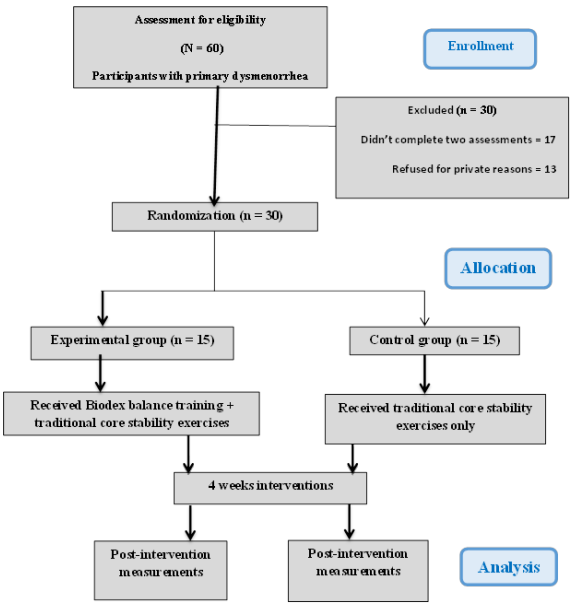

Fig. 1: Flow Chart of the study design

Patient specific functional scale (PSFS) was used to assess the functional abilities of participants, PSFS is a functional assessment scale that assists adult patients to quantify the influence pain and disability have on their ability to achieve activities of daily living. participants were asked to rate five activities of daily living (attending class, cleaning the room, walking, climbing stairs, and self-care). Zero represents being unable to perform the activity, while "10" represents being able to perform the activity at their previous level. The subjects chose a value that accurately describes their level of ability in each activity assessed [18]. PSFS scores have been taken firstly before the menstrual cycle, secondly during the menstrual cycle, and lastly after the treatment intervention.

Figure 2: Biodex Balance System

Balance assessment

The session was started to calculate posturalstability and limit of stability indexes with the balance platform in the "locked" or static position to record participants' heel and foot position on the platform [16]. The participants were instructed to keep their hands at their sides. Handrails could only be touched as a safety precaution during extreme postural deviations to reestablish balance [19].

The participants were assessed on two types of tests: firstly, the postural stability test (Fig.3) to assess the ability to keep the center of balance [15]. We set three test trials of 10-sec tests each at an initial and ending platform setting level of 10 with 5-sec rest between trials. Using the overall stability index is assessed the balance control in all directions for each subject. Secondly, the limit of stability test (LOS) (Fig.4), It requires participants to move and assess control of their center of gravity within their base of support [20]. We set three trials of test with 5-sec rest between trials, the limits of stability hold time were 0.25 sec and the level of platform setting was 10. Using the overall stability index and time to complete the test in all directions for each subject. All the 3-time assessments have been taken before, during menstrual cycle and after treatment intervention with the same procedure explained above.

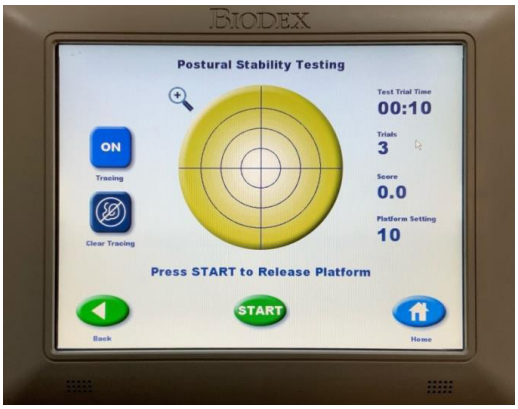

Fig. 3: Postural stability test

Figure 4: Limit of stability test

Treatment program

Traditional Core stability exercises

Traditional Core stability exercises were delivered to both control and experimental groups. The experimental group received sessions on Biodex Balance training in addition to the traditional Core stability exercises.

Both groups received the same traditional Core stability exercises for 4 weeks, three times a week, for 30 min each. The treatment session was including a set of exercises aimed at improving balance, muscle strength and stability [21]. Each session comprises three phases: warm-up, actual training, and cool-down. 5-min consisting of slow running, and gentle stretching exercises for the quadriceps, hamstring, calf and iliopsoas muscles were included in the warm-up activities. The active phase lasted 20 min and was performed on the Mat. The exercises performed under supervision which is included: Crunch with feet on the ball, Ball hip adduction, Wall squat, and ball pendulum. After the exercise, there was a 5-minute cool-down phase that included deep breathing exercise and relaxation exercise. The experimental group received the balance training program three sessions per week for a duration of 4 weeks on BBS which includes postural stability and limits of stability training.

Biodex Balance Training

On Postural stability training, the participants were instructed to stand 5 min on the foot platform and stabilize themselves to keep the pointer in the middle of co-centered circle on the screen. The stability level of the platform was set to 10 for the first 3 sessions and then reduced one level on every 3 sessions so that in the 10th, 11^{th,} and 12th sessions the stability level was 7.

On limits of stability training, the subject attempted to move through a movement pattern consistent with the sway envelope. The sway envelope is the area in which a person's center of gravity (COG) can be moved. We set three trials with 5-sec rest between them and hold time for 0.25 sec.

The stability level of the platform was set to 10 for 1st week and then reduced one level for every week (every three sessions) so that in the 10th, 11th, and 12th sessions the stability level was 7. the subject shifts their weight to move the cursor as quickly and as accurately as possible from a central target to a blinking target and back again.

Data analysis

The data were analyzed using SPSS version 20 (SPSS, Chicago, IL). The descriptive statistics for the mean and standard deviation included the height, weight, age and BMI of the patients. Differences between and within the pre-mid and post-treatment groups were assessed using the student t-test. A P-value below 0.05 was assumed to be significant.

RESULTS

Demographic data

The results of the present study showed no significant difference in demographic data of the patients between experimental and control groups as in **Table 1** for weight, height, age, and BMI variables.

Balance assessment

The results of the present study showed no significant difference in the pre, mid and post-treatment balance assessments, p values were insignificant (P>0.05) between the experimental and control groups for all variables except for post-post treatment assessment for limit of stability (p<0.05).

However, both groups showed improvement in balance when comparing pre, mid and post balance assessment as in Table 2.

Pain assessment

The results of the present study showed no significant difference in mid and post-treatment pain assessments, p-values were insignificant (P>0.05) between the experimental and control groups in post treatment assessment. However, both groups showed improvement in pain when comparing mid and post pain assessment (Table 3).

Functional assessment

The results of the present study showed no significant difference in pre, mid and post-treatment function assessments, p values were insignificant (P>0.05) between the experimental and control groups in post treatment assessment. However, both groups showed improvement in function when comparing mid and post assessment variables (Table 4).

Table 2: Demographic data of the experimental and control group pre-treatment.

Descriptive statistics				
	Age	*Weight*	*Height*	*BMI*
Experimental	21.4 ±.6	49.5 ±8.8	158.1±4.9	19.7±3.2
Control	20.7±1.2	54.4±10.2	158.1±5.5	21.4±3.4
T-value	-2.05	1.42	-0.004	1.43
P value	0.058**	0.165**	0.997**	0.163**

Level of significance at P<0.05, *Significant, **Non-significant.

Table 2: Balance assessment of the experimental and control group pre-mid-post treatment.

Variables		*Experimental group*	*Control group*	*T value*	*P value*
Postural stability	Pre	0.8 ±.3	0.8 ±.3	-0.14	0.892**
	Mid	0.9±.4	0.9±.2	-0.08	0.939**
	Post	0.8 ±.4	0.7±.2	-0.89	0.376**
Limit of stability	Pre	30.2±9.2	30.6±6.6	0.15	0.884**
	Mid	31.7±9.4	31.4±7.4	-0.08	0.940**
	Post	45.9±10.0	37.5±7.3	-2.69	0.012*

Level of significance at P<0.05. *Significant. **Non-significant.

Table 3: Visual analogue scale (pain) of experimental and control group pre-mid-post treatment

	Experimental	*Control*	*T value*	*P value*
Pre	0.0 ±0.0	0.0±0.0	0.00	0.00
Mid	6.5±1.9	5.9±2.4	-0.75	0.461**
Post	3.5±2.3	4.8±2.6	1.44	0.162**

Level of significance at P<0.05., *Significant. **Non-significant.

Table 4: Patient specific functional scale (PSFS) of experimental and control group pre-mid-post treatment

variables		*Experimental group*	*Control group*	*T value*	*P value*
Attend classes	Pre	10.0±0.0	10.0±0.0	0.00	0.00
	Mid	7.5±1.6	7.2±2.9	-0.32	0.749**
	Post	8.7±1.4	8.2±3.0	-0.56	0.581**
Cleaning room	Pre	10.0±.0	10.0±.0	0.00	0.00
	Mid	5.5±1.9	4.6±2.8	-1.03	0.312**
	Post	7.1±1.9	7.0±2.9	-.15	0.881**
Walking longtime	Pre	10.0±.0	10.0±.0	0.00	0.00
	Mid	4.8±1.8	5.2±2.1	0.54	0.592**
	Post	6.8±1.8	7.2±2.5	0.49	0.626**
Climbing stairs	Pre	10.0±.0	10.0±.0	0.00	0.00
	Mid	5.3±1.8	5.9±3.1	.59	0.562**
	Post	7.4±2.1	7.2±2.4	-.26	0.794**
Self-care	Pre	10.0±.0	10.0±.0	0.00	0.00
	Mid	7.9±1.5	7.4±2.3	-0.71	0.486**
	Post	9.0±1.4	8.6±1.9	-0.72	0.475**

Discussion

This study aimed to determine the effect of Biodex balance training on postural stability, pain, and functional activities in patients with primary dysmenorrhea. After 4 weeks of treatment using Biodex balance training in addition to traditional core stability exercises for the experimental group and traditional core stability exercise for the control group, both groups showed improvements in postural stability, functional activities, and pain intensity when comparing mid-post variables but there was no significant difference in the mean values between the two groups.

The BBS is a multi-axis device that objectively assesses and records a person's capacity to stabilize a joint under dynamic stress appropriately [22]. Several studies evaluated the effects of balance training via BBS on different balance parameters of different pathologies with balance problems and found positive results. But the use of BBS to train and enhance balance in dysmenorrhea cases is considered a new tool and has been used in several studies as a measurement tool, not as a treatment tool.

BBS improves postural stability by putting stress on the somatosensory system, thus promoting information concerning balance. Moreover, the visual biofeedback system of BBS also plays a major role in the enhancement of balance, as it provides greater sensory information about sole pressure 23. Balance and joint proprioception are mediated by the same afferent mechanism and are suggested to be - dependent upon the inherent ability to integrate joint position sense, kinesthesia, and neuromuscular control 24. Our result came in agreement with Siddiqi and Masood9 who found a significant improvement in subjects' balance and mobility in the study group after eight weeks of the treatment program to improve balance and mobility for elderly subjects by BBS for the study group, authors said that dynamic postural balance training using biodex balance system had a positive effect on balance and mobility in healthy older subjects and can be used as a training tool to improve balance and mobility and reduce fall risk. Another study by Eftekhar-Sadat et al. 10 supported our results as they stated that after 10 sessions of balance training with Biodex for moderate to severe diabetic neuropathy cases, the results of their study had been shown improvement in mobility and balance. El-Gohary et al.25 conducted a study on forty-eight children with spastic diplegic cerebral palsy and divided them into two groups to see the effect of the BBS versus conventional balance training on balance and gross motor function. The experimental group trained on Biodex as well as traditional physiotherapy program training, while the control group received traditional balance training as well as traditional physical therapy program training. Balance training with the BBS was found to be more effective and improved the integration of various sensory inputs, leading to improved balance and postural control than conventional balance training in improving balance and gross motor functions. Virtual reality-based training by BBS in multiple sclerosis patients showed significant improvement in balance and decrease the risk of fall 26. Our study supports all previous studies, the results of present study showed improvement in postural stability for both groups when comparing pre and post-treatment data, but the mean difference between the two groups was insignificant, which could be attributed to the small sample size or the short treatment period.

Regarding functional activity of daily living, there was an improvement in all functional activities scores after treatment. Our result comes in agreement with Daud et al. [27] who found improvement in balance and motor function in diabetic neuropathy patients, after training on BBS, there is a significant difference in Timed Up and Go test and Berg Balance Scale (BBS) scores after treatment. Another two studies recorded progress in postural control after balance training, also they further said that postural adjustment improves movement quality by providing a secure base during active extremity activity [28,29]. Also, the programs used Biodex in the rehabilitation of neurological cases to return the affected motor skills

through re-training new neural pathways, proprioception, and maintenance of position, balance, and weight transfer. All of this will improve the performance of doing activities of daily living [30]. Another study reported that training with biodex for ten-weeks exercise increases functional performance, stability, proprioception, and reduces sway for grade II and III bilateral knee osteoarthritis patients [31].

Regarding pain intensity level (VAS), pain is considered a secondary improvement, when balance and function are improved, it will facilitate the work of daily functions without pain, our result comes in agreement with Javed et al.[31] who reported that Biodex training was effective in decrease pain level in knee osteoarthritis patients and with Hosseinifar et al. [32] who concluded that Biodex Balance System effectively reduced the severity and the chances of having non-specific chronic low back pain. Our result showed a reduction in pain in both groups after the treatment periods. However, there is no difference was found between the experimental and control groups.

LIMITATIONS

This study had some limitations. First, the sample size was small to show statistical differences between groups. Second, the treatment period was short to achieve better results. Further studies are recommended with a large sample size and longer treatment period.

CONCLUSION

Balance training with BBS has a positive effect on dysmenorrhea patients by improving postural stability, functional activities, and decreasing pain intensity.

Acknowledgments

The authors had no Acknowledgments

Funding:

No funding support for this research.

Conflict of interest:

The authors declared no potential conflicts of interest with respect to publication of this study.

Ethical approval:

The study was approved by the biomedical research Ethics Committee at Umm Al-Qura University, approval no (HAPO-02-K-012-2022-02-947).

Informed consent:

Before signing an informed consent form accepting to participate in the study, all subjects were given a full explanation of the study's procedures, objectives, and hazards.

AUTHOR CONTRIBUTIONS:

Treatment plan, data collection, and designing the study was done by all authors. All authors contributed in reviewing the final version of this paper.

REFERENCES

1. Osayande AS, Mehulic S. Diagnosis and initial management of dysmenorrhea. Am Fam Physician. 2014;89(5):341-6.
2. Gerzson LR, Padilha JF, Braz MM, Gasparetto A. Physiotherapy in primary dysmenorrhea: literature review. Revista Dor, 2014;15, 290-295.▫
3. Abu Helwa HA, Mitaeb AA, Al-Hamshri S, Sweileh WM. Prevalence of dysmenorrhea and predictors of its pain intensity among Palestinian female university students. BMC Women's Health, 2018;18(1): 1-11.. doi: 10.1186/s12905-018-0516-1.
4. Ferries-Rowe E, Corey E, Archer JS. Primary dysmenorrhea: Diagnosis ther Obstet Gynecol. 2020;136(5):1047-1058. doi: 10.1097/AOG.0000000000004096.
5. Ju H, Jones M, Mishra G. The prevalence and risk factors of dysmenorrhea. Epidemiol Rev. 2014;36:104-13. doi: 10.1093/epirev/mxt009.
6. Schoep ME, Adang EMM, Maas JWM, De Bie B, Aarts JWM, Nieboer TE. Productivity loss due to menstruation-related symptoms: a nationwide cross-sectional survey among 32 748 women. BMJ Open, 2019;9(6):e026186. doi: 10.1136/bmjopen-2018-026186.
7. Petrofsky J, Lee H. Greater reduction of balance as a result of increased plantar fascia elasticity at ovulation during the menstrual cycle. Tohoku J Exp Med. 2015;237(3):219-26. doi: 10.1620/tjem.237.219.
8. Lee SW, Shin WS. Comparison of the effects of pilates and aerobic exercise on pain, menstruation symptoms, and balance in women with dysmenorrhea. J Korean Phys The. 2021; 33(5), 238-244.
9. Siddiqi FA, Masood T. Training on Biodex balance system improves balance and mobility in the elderly. J Pak Med Association. 2018 68(11):1655-1659.
10. Eftekhar-Sadat B, Azizi R, Aliasgharzadeh A, Toopchizadeh V, Ghojazadeh M. Effect of balance training with Biodex Stability System on balance in diabetic neuropathy. Ther Adv Endocrinol Metab. 2015;6(5):233-40. doi: 10.1177/2042018815595566.
11. Sung ES, Kim JH. The influence of ovulation on postural stability (Biodex Balance System) in young female. J Exerc Rehabil. 2018;14(4):638-642. doi:10.12965/jer.1836266.133.
12. Kami AT, Vidigal CB, Macedo CD. Influence of menstrual cycle phases in functional performance of healthy and young women. Fisioterapia e Pesquisa, 2017; 24, 356-362.
13. Lee BJ, Cho KH, Lee WH. The effects of the menstrual cycle on the static balance in healthy young women. J Phys Ther Sci. 2017;29(11):1964-1966. doi:10.1589/jpts.29.196.
14. Durand H, Monahan K, McGuire BE. Prevalence and impact of dysmenorrhea among university students in Ireland. Pain Med. 2021;22(12):2835-2845. doi: 10.1093/pm/pnab122.
15. Abdelaal A, El-Shamy S. Effects of antigravity treadmill training on gait and balance in patients with diabetic polyneuropathy: A randomized controlled trial. F1000Res. 2022;11(52), 52.
16. Ibrahim ZM, Ali OI, Moawd SA, Eid MM, Taha MM. Low vibrational training as an additional intervention for postural balance, balance confidence and functional mobility in type 2 diabetic patients with lower limb burn injury: A randomized clinical trial. Diabetes Metab Syndr Obes. 2021;14:3617-3626. doi: 10.2147/DMSO.S307414.
17. Schmidt S, Wölfle N, Schultz C, Sielmann D, Huber R, Walach H. Assessment of a taping method combined with manual therapy as a treatment of non-specific chronic low back pain: A randomized controlled trial. BMC Musculoskelet. Disord. 2021;22(1):410. doi: 10.1186/s12891-021-04236-2.
18. Verbrugghe J, Agten A, Stevens S, Hansen D, Demoulin C, Eijnde BO, Vandenabeele F, Timmermans A. High intensity training to treat chronic nonspecific low back pain: Effectiveness of various exercise modes. J Clin Med. 2020;9(8):2401. doi: 10.3390/jcm9082401.
19. Allet L, Armand S, de Bie RA, Golay A, Monnin D, Aminian K, Staal JB, de Bruin ED. The gait and balance of patients with diabetes can be improved: a randomised controlled trial. Diabetol. 2010;53(3):458-66. doi: 10.1007/s00125-009-1592-4.

20. Shih MC, Wang RY, Cheng SJ, Yang YR. Effects of a balance-based exergaming intervention using the Kinect sensor on posture stability in individuals with Parkinson's disease: a single-blinded randomized controlled trial. J Neuroeng Rehabil. 2016; 13(1): 1-9.
21. Shahrjerdi S, Mahmoudi F, Sheikhhoseini R, Shahrjerdi S. Effect of core stability exercises on primary dysmenorrhea: A randomized controlled trial. J Modern Res. 2019;13(2):113-122.
22. Ibrahim MS, Mattar AG, Elhafez SM. Efficacy of virtual reality-based balance training versus the Biodex balance system training on the body balance of adults. J Phys Ther Sci. 2016;28(1):20-6. doi: 10.1589/jpts.28.20. Epub 2016 Jan 30.
23. Ahmed GM, Tawfik RM, Amer H A, Mansour WT, Battesha HH. Influence of visual feedback training on distribution of foot pressure in diabetic neuropathy patients. Intl J Diabetes Res. 2017 6(4):73-82.
24. Losse GM, Howward ME, Cawley PW, Philipe J, Doutbit BE: Correlation of lower extremity injury to balance indices: An investigation utilizing an instrumented unstable platform. Am Orthopa Soc Sports Med. 1994; 50-52.
25. El-Gohary TM, Emara HA, Al-Shenqiti A, Hegazy FA. Biodex balance training versus conventional balance training for children with spastic diplegia. J Taibah Univ Med Sci. 2017; 12(6):534-540. doi:10.1016/j.jtumed.2017.07.002.
26. Eftekharsadat B, Babaei-Ghazani A, Mohammadzadeh M, Talebi M, Eslamian F, Azari E. Effect of virtual reality-based balance training in multiple sclerosis. Neurol Res. 2015;37(6):539-44. doi: 10.1179/1743132815Y.0000000013.
27. Daud SAH, Rahman MU, Arsh A, Junaid M. Effect of balance training with Biodex Balance System to improve balance in patients with diabetic neuropathy: A quasi experimental study. pak J Med Sci. 2021;37(2):389-392. doi:10.12669/pjms.37.2.2336.
28. Bahramizadeh M, Mousavi ME, Rassafiani M, Aminian G, Ebrahimi I, Karimlou M, Toole GO. The effect of floor reaction ankle foot orthosis on postural control in children with spastic cerebral palsy. Prosthet Orthot Int. 2012;36(1):71-6. doi: 10.1177/0309364611429855.
29. El-Shamy SM, Abd El Kafy EM. Effect of balance training on postural balance control and risk of fall in children with diplegic cerebral palsy. Disabil Rehabil. 2014;36(14):1176-83. doi: 10.3109/09638288.2013.833312.
30. Cachupe WJ, Shifflett B, Kahanov L, Wughalter EH. Reliability of biodex balance system measures. Meas Phys Educ Exerc Sci. 2001; 5(2):97-108
31. Javed S, Riaz H, Saeed A, Begum R. Effects of biodex balance training on symptomatic knee osteoarthritis in Rawalpindi: A randomized control trial. J Pak Med Association, 2021;71(2(A)):402-405. doi: 10.47391/JPMA.331.
32. Hosseinifar M, Akbari A, Mahdavi M, Rahmati M. Comparison of balance and stabilizing trainings on balance indices in patients suffering from nonspecific chronic low back pain. J Advanced Pharma Technol Res. 2018;9(2):44-50. doi:10.4103/japtr.JAPTR_130_18.