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STAR EXCURSION BALANCE TEST NORMATIVE VALUE IN YOUNG ADULTS - A CROSS-SECTIONAL STUDY

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Abstract: **Background:** The Star Excursion Balance Test (SEBT) is a simple, reliable, and cost-effective screening tool used to evaluate dynamic balance in eight selective directions. SEBT reach distance values serve as indicators of dynamic postural control. Despite its global use, normative values for healthy young adults are not yet established.

Purpose: To evaluate the normative value of the star excursion balance tool in young adults.

Methodology: A cross-sectional study was done to establish normative values for the SEBT in 1000 young adults (both males and females) aged 17 to 30 years, encompassing diverse heights and BMI ranges. Individuals were required to maintain balance on one lower extremity and perform three trials of the SEBT on both sides. An average score of 3 trials is considered for data analysis.

Result: A total 1000 number of individuals (male and female) with a mean age of male (22.0921) and mean age of female (21.4494) were selected for the study and according to height and BMI normative values were recorded in both genders in each direction for both right and left side.

Conclusion: This study successfully finds the normative value of SEBT in each direction according to gender, height, weight, and BMI. So, the researcher and clinician can use this established value as a reference for assessment as well as monitoring patient progression. Also, the coaches used this value to assess as well as manage their players thus, the injury can be avoided.

Keywords: SEBT, Normative value, Dynamic balance, Functional performance

INTRODUCTION

Balance is essential to all functional movement. This is a fundamental aspect of all the day to day activities. Balance is crucial for daily activities such as standing on toes, reaching, walking on uneven surfaces, running, swimming, dancing and bike riding etc. Any impairment in balance can lead to decrease performance and increase the risk of injury and fractures, lead to disruption in daily tasks. Thus, balance is an important therapeutic consideration in any rehabilitation programme. [1, 2]

Balance, also known as postural stability, refers to the dynamic process by which the body's position is kept in equilibrium. Equilibrium indicates that the body is either at rest (static equilibrium) or in steady motion (dynamic equilibrium).[3] Balance is commonly linked to stability and postural control. Postural control is defined as the act of maintaining, achieving or restoring a state of balance during any posture or activity.[4]

Postural control measurement is crucial for assessing neuromuscular function in paediatric, geriatric, and sports populations to prevent injuries and improve rehabilitation. Postural control and balance can be classified into two categories; [5, 6]

• Static balance
• Dynamic balance

Static balance is defined as keeping a stable antigravity position at rest, such as standing and sitting, or holding a position with very little movement. These can be assessed using instrumented equipment like a force platform, reliable clinical scales like the Balance Error Scoring System, and modified Rhomberg tests, stroke stance test, single leg stance and Romberg test. [3, 5, 6]

Dynamic balance is defined as maintaining a steady base of support while performing a prescribed movement or stabilising the body when the support surface is shifting or when the body is moving on a stable platform, such as sit-to-stand transfers or walking. This can include tasks like jumping or hopping to a new area while remaining stationary, or creating purposeful segment movements (reaching) without compromising support. Numerous tests have been developed to assess dynamic postural control in the paediatric, neurological and geriatric populations which includes Tinetti Performance Oriented Mobility Assessment (POMA), Timed Up and Go Test (TUG), Berg Balance Scale, Gait Abnormality Rating Scale (GARS) and Dynamic Gait Index (DGI) but very few tests that truly stress the dynamic balance capabilities of the healthy, athletic population. Therefore, it's crucial to find reliable, sensitive, and cost-effective assessment tools for understanding dynamic movement. [3, 5, 6]

There are limited practical ways for testing dynamic balance, such as force plate analysis and modified bass tests. However, this equipment is often too expensive and spaceconsuming for many clinical settings.[1] Thus, a simple, reliable, and valid test is needed to measure dynamic balance.

The Star Excursion Balance Test (SEBT) is a quick, reliable, and cost-effective way to assess dynamic balance of the lower limb, monitor rehabilitation progress, assess deficits after injury, and identify athletes at high risk for lower extremity injury. SEBT needs neuromuscular abilities such as lower extremity coordination, balance, flexibility, and strength.[1]

In the present era, the SEBT is a simple and cost-effective test that is quick to administer and typically accessible in all clinical field settings. The main advantage of this test is to assess the balance in all directions, less sophisticated in terms of cost & less time-consuming as compared to other tests available in the literature. It is the only test that measure the balance in all 8 directions (anterior, anteromedial, medial, posteromedial, posterior, posterolateral, lateral and anterolateral).[1]

Even though SEBT is a good & reliable test, the normative value & interpretation for the same are lacking in the literature. So, the finding of the normative value of SEBT has attracted attention, but to the best of our knowledge, there is a scarcity of literature available that determines the normative value of SEBT. Thus, the aim of the present study is to determine the normative values of star excursion balance test in young adults.

RESEARCH METHODOLOGY

This cross-sectional was done on healthy young adults and data were collected from various departments of S.S Agrwal college, Navsari, Gujarat. For, the collection of data purposive sampling technique was used.

Sample size

The expected probability of high normative value was assumed to be 50%, and by applying a 95% power, precision of +5%, and a design effect of 1.0, the minimum required sample size was estimated to be 384 participants. But, for better precision and to reduce unforeseen errors, the opted sample size was 1000.

Inclusion criteria

- Individual with age between 17-30 years
- Both gender male and female
- Full ROMs of all lower limb joints
- Stable medical condition
- Mini Mental Scale examination ≥ 24

Exclusion criteria

- Recent history of lower limb surgery/trauma
- Pre-existing functional limitation of the lower limb
- Neurological deficits
- History of malignancy
- Perceptual, visual, or vestibular deficits
- Presence of any systematic disease

Procedure

In this cross-sectional study, a total of 1000 individuals were purposively selected from different colleges based on the inclusion and exclusion criteria. After screening, all the individuals were explained and demonstrate the present study, and written informed consent were signed by all the individuals towards their willingness to participate. Demographic data and baseline characteristics of the individuals were collected using the assessment form.

Formation of Star Excursion Balance

Test Before the SEBT can be done, certain preparation is necessary.

For, formation of SEBT four pieces of athletic tape must be cut to a length of 6-8 feet each. Then, 2 pieces will be used to construct a '+', with the remaining two placed on top to form a 'x', resulting in a star shape. Make sure all lines must be separated at a 45° angle.

Procedure for SEBT[1]

The assessor demonstrated the test to all of the test individuals. Individuals were instructed to place one foot in the centre of the star pattern and use the other foot to reach out and softly touch the line with their big toe before returning to the starting position. The assessor used a marker to mark where the individual touched the line. The length of reach (linear distance) was measured in all eight directions using a measuring tape. After the test, the linear distance from the centre location was measured to compute the reach distance in each direction. When utilising the right foot as the reaching foot and the left leg to balance, the individual completed the circle clockwise, whereas when balancing on the right leg, the circuit was conducted anti-clockwise. The

individual was advised to repeat the practice three times in each direction, using both feet. They were allowed 15 seconds to relax between reaches. The average of three reaches per leg in each of the eight directions was computed.

The trial was deleted and redone with the individual.

- Does not touch the line with the reach foot while keeping the weight on the stance leg.
- Lifted the stance foot off the central grid.
- Lost balance at any time during the test.
- Could not hold the start and return positions for a complete second.
- If the accessor determined that a volunteer's reach foot provided significant support to their body.

SEBT performance was assessed for both the right and left leg, and the average reach distance was computed using the equation below.

Everage distance in each direction (cm): Reach 1 + Reach 2 + Reach 3/3

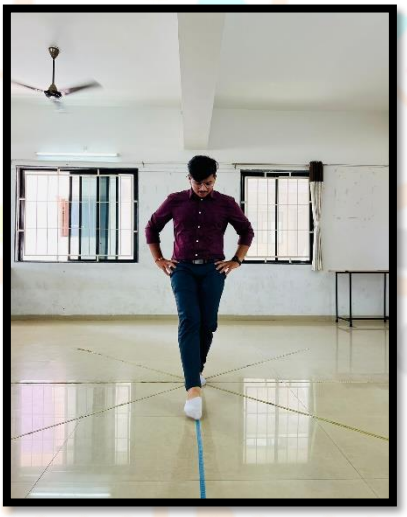

Figure 1: Individual performing the anterior direction of SEBT

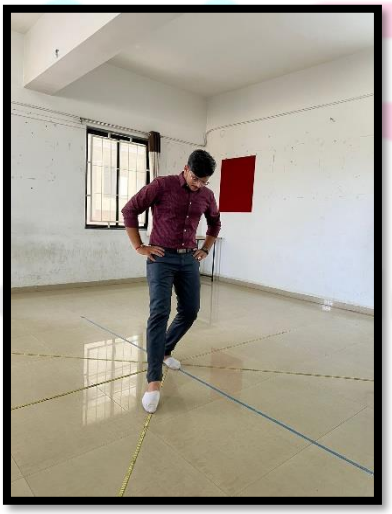

Figure 2: Individual performing the anteromedial direction of SEBT

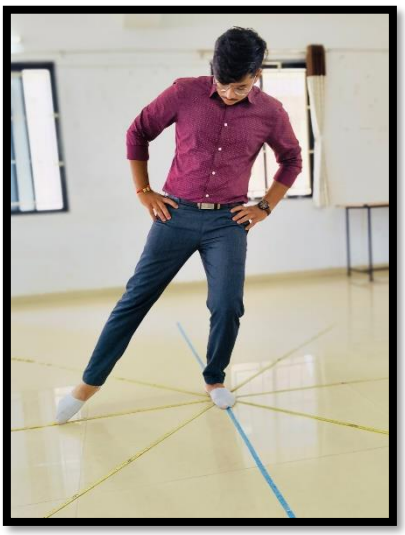

Figure 3: Individual performing the medial direction of SEBT

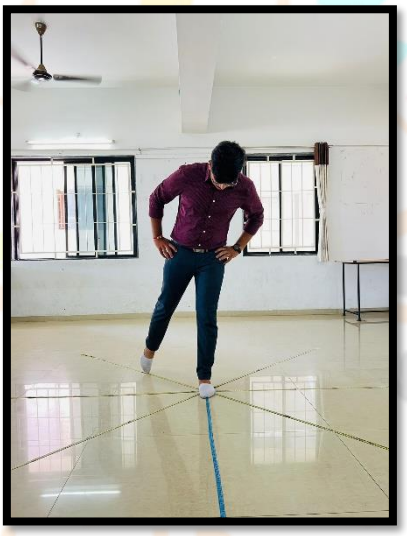

Figure 4: Individual performing the posteromedial direction of SEBT

Figure 5: Individual performing the posterior direction of SEBT

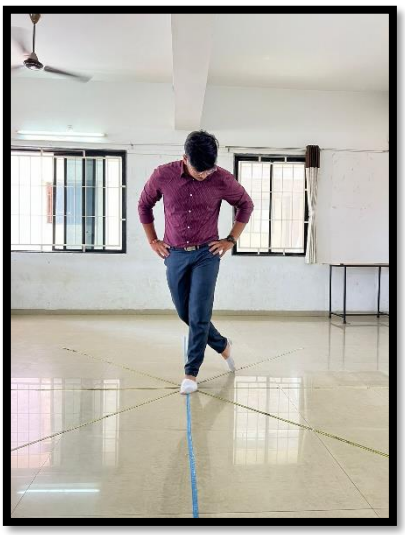

Figure 6: Individual performing the posterolateral direction of SEBT

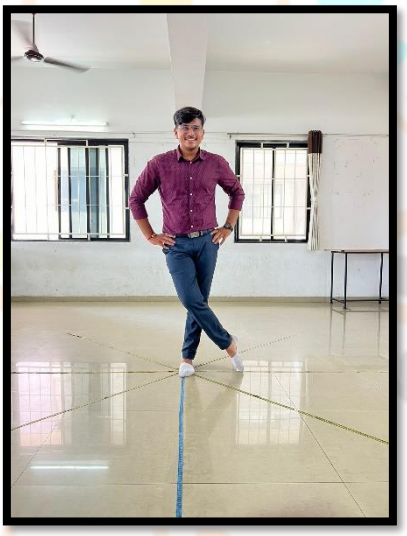

Figure 7: Individual performing the lateral direction of SEBT

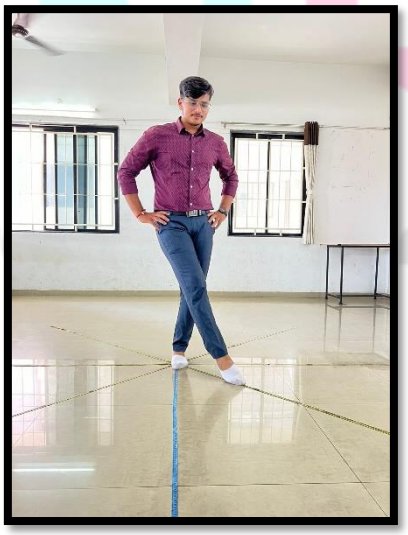

Figure 8: Individual performing the anterolateral direction of SEBT

STATISTICAL ANALYSIS

Results were considered to be significant at $p<0.05$ and the confidence interval was set at 95%. All statistical analysis was performed using SPSS version 25.

The following Statistical analysis was done:

• Descriptive statistics including mean and standard deviation were analysed.

RESULTS

Table 1: Gender Distribution of Individuals

	Male	**Female**	**Total**
Frequency	239	761	1000
Percentage	23.9%	76.1%	100%

Table 1 shows the Gender Distribution of all 1000 individuals, in that 239 are males and 761 are females.

Table 2: Demographic Details

	Male	**Female**
Age (years) Mean ± SD	22.0921±3.02509	21.4494±2.04177
Height(cm) Mean ± SD	168.8092±9.63199	157.7578±7.35987
BMI(KG/m²) Mean ± SD	22.2827±4.05399	20.8179±4.15223

Table 2 shows the Descriptive Statistics of Age, Height, BMI among 239 males and 761 females.

Table 3: Normative Value of SEBT for Male and Female

SEBT Directions	Mean	Standard Deviation
Right Anterior	60.2815	7.67443
Right Anteromedial	62.0223	8.20176
Right Medial	60.5060	8.42585
Right Posteromedial	57.4881	9.25834
Right Posterior	50.9883	8.72099
Right Posterolateral	49.8174	8.63028
Right lateral	51.3131	7.53527
Right anterolateral	56.8274	7.65176
Left Anterior	58.0691	8.03396
Left Anteromedial	59.9859	8.85511
Left Medial	58.1052	8.61633
Left Posteromedial	54.1936	9.25781
Left Posterior	50.3785	8.68152
Left Posterolateral	49.3162	9.05580
Left Lateral	53.5551	7.62633
Left Anterolateral	57.6092	7.74186

Table 3 shows the Normative Value of each direction of SEBT for all the 1000 individuals.

Table 4: Normative Value of SEBT for Male

SEBT Directions	Mean	Standard Deviation
Right Anterior	64.4110	8.50342
Right Anteromedial	65.9135	9.65110
Right Medial	64.3710	10.03416
Right Posteromedial	61.3975	10.60119
Right Posterior	55.2678	9.42846
Right Posterolateral	54.8842	9.16913
Right lateral	54.1785	8.41555
Right anterolateral	60.6541	8.70683
Left Anterior	62.6434	8.88776
Left Anteromedial	63.7759	10.11482
Left Medial	61.6164	9.71442
Left Posteromedial	58.0995	10.11458
Left Posterior	54.8646	9.66645
Left Posterolateral	54.3615	10.00406
Left Lateral	57.1427	8.73503
Left Anterolateral	61.8489	8.58118

Table 4 shows the Normative Value of each direction of SEBT for males.

Table 5: Normative Value of SEBT for Female

SEBT Directions	Mean	Standard Deviation
Right Anterior	58.9845	6.90851
Right Anteromedial	60.8002	7.27994
Right Medial	59.2921	7.45773
Right Posteromedial	56.2603	8.43579
Right Posterior	49.6443	8.03535
Right Posterolateral	48.2262	7.80817
Right lateral	50.4132	7.01029
Right anterolateral	55.6256	6.86807
Left Anterior	56.6325	7.17344
Left Anteromedial	58.7957	8.06828
Left Medial	57.0024	7.93350
Left Posteromedial	52.9669	8.62079
Left Posterior	48.9382	7.81776
Left Posterolateral	47.7317	8.12015
Left Lateral	52.4284	6.87299
Left Anterolateral	58.2777	6.94961

Table 5 shows the Normative Value of each direction of SEBT for females.

Table 6: Normative SEBT Values of Right Stance in Male with Different Height

SEBT Directions	141-150cm	151-160cm	161-170cm	171-180cm	181-190cm	191-200cm
	N = 7	N =46	N = 80	N = 81	N =23	N = 2
Anterior	51.76±3.18	59.28±5.25	64.02±8.59	67.09±7.67	70.02±8.70	68.83±0.70
Anteromedial	54.23±4.02	61.31±6.28	65.45±9.87	68.20±8.83	72.05±11.88	67.00±1.88
Medial	47.85±5.40	60.12±6.48	64.13±9.87	66.36±8.76	71.71±13.00	64.00±4.24
Posteromedial	46.09±8.37	57.65±7.23	60.78±10.64	62.90±9.41	69.78±12.85	67.66±10.37
Posterior	45.09±6.75	50.28±6.71	54.55±8.50	57.30±9.25	62.60±10.42	67.33±11.31
Posterolateral	44.19±7.64	49.00±6.48	53.83±8.09	58.22±9.24	61.18±7.87	61.83±0.23
Lateral	47.09±8.40	50.14±5.87	54.44±7.74	55.20±9.35	58.65±7.022	68.16±3.53
Anterolateral	47.85±7.12	55.69±6.53	60.36±7.78	62.74±8.25	67.05±8.49	73.00±9.89

Table 6 shows normative values for the Star Excursion Balance Test (SEBT) in right stance among male individuals categorized by different height ranges.

Table 7: Normative SEBT Values of Left Stance in Male with Different Height

SEBT Directions	141-150cm	151-160cm	161-170cm	171-180cm	181-190cm	191-200cm
	N = 7	N = 46	N = 80	N = 81	N = 23	N = 2
Anterior	49.92±2.10	57.33±6.85	62.51±7.99	64.97±8.70	69.26±8.71	64.00±0.94
Anteromedial	52.44±5.69	58.07±6.55	62.72±9.01	66.73±10.18	71.56±11.42	67.16±3.06
Medial	47.71±6.61	56.32±6.31	60.25±8.60	64.80±8.67	69.65±12.37	64.83±6.83
Posteromedial	49.25±6.62	52.71±9.00	56.52±9.10	61.13±9.28	65.84±11.01	63.83±6.83
Posterior	42.93±3.87	50.87±8.43	53.06±8.41	58.42±9.14	60.60±11.12	62.16±7.03
Posterolateral	44.07±7.74	49.28±8.04	53.28±9.45	57.21±9.80	60.27±9.58	66.33±0.47
Lateral	47.25±8.37	54.02±6.95	57.45±8.29	57.80±9.42	62.21±6.88	65.66±8.48
Anterolateral	49.93±3.37	57.84±6.33	62.38±8.63	63.20±8.32	66.42±8.90	66.83±4.94

Table 7 shows normative values for the Star Excursion Balance Test (SEBT) in left stance among male individuals categorized by different height ranges.

Table 8: Normative SEBT Values of Right Stance in Female with Different Height

SEBT Directions	131-140cm	141-150cm	151-160cm	161-170cm	171-180cm	181-190cm (2)
	N = 10	N = 101	N = 385	N = 235	N = 28	N = 2
Anterior	54.10±6.23	56.0±6.23	59.13±6.88	59.80±6.91	62.91±5.53	51.66±2.35
Anteromedial	53.00±5.64	57.11±7.44	60.70±6.78	62.20±7.20	66.65±6.53	58.16±5.89
Medial	50.80±4.11	56.28±7.00	59.25±7.08	60.38±7.53	64.54±8.57	58.50±2.12
Posteromedial	49.06±6.64	51.70±8.68	56.72±8.12	57.06±7.90	61.65±9.29	62.83±8.24
Posterior	43.56±5.39	45.64±7.77	49.78±7.78	50.69±7.75	54.63±8.75	60.33±11.78
Posterolateral	41.23±6.00	45.51±7.75	48.23±7.69	48.92±7.64	54.19±6.52	53.50±4.47
Lateral	43.96±6.86	47.28±7.20	50.51±6.89	51.32±6.58	54.95±6.47	49.83±6.36
Anterolateral	46.00±4.45	52.03±6.78	55.60±6.88	56.89±5.89	61.73±6.42	55.33±0.00

Table 8 shows normative values for the Star Excursion Balance Test (SEBT) in right stance among female individuals categorized by different height ranges.

Table 9: Normative SEBT Values of Left Stance in Female with Different Height

SEBT Directions	131-140cm	141-150cm	151-160cm	161-170cm	171-180cm	181-190cm
	N = 10	N = 101	N = 385	N = 235	N = 28	N = 2
Anterior	48.26±6.22	53.37±7.66	56.40±6.90	58.19±6.46	61.47±8.11	55.50±1.17
Anteromedial	49.00±6.26	55.89±8.20	58.66±8.10	59.95±7.27	64.67±7.77	61.16±4.47
Medial	48.76±6.29	53.16±8.31	57.40±7.86	58.08±7.17	62.70±7.19	58.66±2.82
Posteromedial	46.33±6.58	49.47±8.72	53.01±8.55	54.07±8.12	58.17±9.03	51.33±2.82
Posterior	41.93±5.16	46.27±8.33	48.78±7.78	50.10±7.26	53.10±7.66	52.16±2.59
Posterolateral	40.60±6.01	44.34±8.34	48.05±7.69	48.36±8.26	52.75±7.4	48.33±8.01
Lateral	43.46±5.58	50.63±8.01	52.44±6.48	52.89±6.40	57.79±7.28	54.33±6.12
Anterolateral	47.76±5.35	53.63±7.74	55.99±6.67	57.57±6.20	61.89±7.65	55.83±1.17

Table 9 shows normative values for the Star Excursion Balance Test (SEBT) in left stance among female individuals categorized by different height ranges.

Table 10: Normative SEBT Values of Right Stance in Male with Different BMI

SEBT directions	<18.5 KG/M²	18.5-24.9KG/M²	25.0-29.9KG/M²	30-34.9KG/M²	35-39.9KG/M²
	N = 54	N = 140	N = 29	N = 12	N = 4
Anterior	65.87±8.25	64.60±8.71	62.22±8.39	62.08±7.60	60.75±4.08
Anteromedial	67.34±11.37	66.23±8.96	63.24±10.06	63.80±8.35	60.91±3.64
Medial	65.59±11.66	64.57±9.46	61.62±9.54	65.25±9.94	57.83±7.62
Posteromedial	62.53±11.87	61.84±10.09	58.78±10.49	59.55±10.94	55.00±8.13
Posterior	56.19±9.74	55.62±9.09	51.93±10.11	56.75±10.27	50.16±5.13
Posterolateral	56.93±7.66	55.13±9.47	51.58±8.81	52.83±10.93	48.33±6.80
Lateral	57.66±6.92	54.02±8.09	51.22±8.59	49.30±11.43	48.50±11.19
Anterolateral	63.29±8.75	60.78±8.15	57.04±10.10	57.86±8.03	55.08±7.84

Table 10 shows normative values for the Star Excursion Balance Test (SEBT) in right stance among male individuals categorized by different BMI ranges.

Table 11: Normative SEBT Values of Left Stance in Male with Different BMI

SEBT directions	<18.5 KG/M²	18.5-24.9KG/M²	25.0-29.9KG/M²	30-34.9KG/M²	35-39.9KG/M²
	N = 54	N = 140	N = 29	N = 12	N = 4
Anterior	64.35±9.11	62.81±8.58	59.86±9.58	61.16±9.60	58.25±4.70
Anteromedial	66.04±10.22	63.72±9.82	60.31±10.75	63.47±10.71	60.75±8.67
Medial	62.43±9.64	62.07±9.48	69.19±11.16	59.44±9.51	58.75±8.43
Posteromedial	58.94±8.67	58.23±10.82	56.50±10.74	56.77±7.57	57.41±4.81
Posterior	55.96±8.99	54.78±10.04	55.02±10.52	52.66±7.77	54.08±3.03
Posterolateral	55.66±8.68	54.52±10.25	52.22±10.59	52.33±8.67	52.41±17.64
Lateral	60.25±7.35	56.54±8.47	56.34±9.75	54.13±9.33	50.75±16.64
Anterolateral	63.17±8.58	62.10±8.31	59.95±9.62	59.25±8.49	56.58±8.34

Table 11 shows normative values for the Star Excursion Balance Test (SEBT) in left stance among male individuals categorized by different BMI ranges.

Table 12: Normative SEBT Values of Right Stance in Female with Different BMI

Table 12 shows normative values for the Star Excursion Balance Test (SEBT) in right stance among female individuals categorized by different BMI ranges.

SEBT directions	<18.5 KG/M²	18.5-24.9KG/M²	25.0-29.9KG/M²	30-34.9KG/M²	35-39.9KG/M²	≥40KG/M²
	N = 54	N = 397	N = 90	N = 16	N = 3	N = 1
Anterior	58.13±6.89	59.41±6.90	59.35±6.86	58.93±5.43	55.77±3.02	79.00±0.00
Anteromedial	60.25±6.66	61.25±7.45	60.31±7.99	60.10±6.62	57.22±4.78	81.33±0.00
Medial	58.19±7.04	59.84±7.78	59.66±7.00	60.79±5.10	53.77±3.23	78.33±0.00
Posteromedial	55.41±8.57	56.70±8.38	56.36±8.08	58.72±6.90	47.44±10.85	73.00±0.00
Posterior	48.87±8.42	49.77±7.94	50.83±6.97	52.39±7.40	42.55±10.66	64.33±0.00
Posterolateral	47.45±7.51	48.70±7.95	47.77±7.32	51.16±5.57	43.66±15.37	60.33±0.00
Lateral	50.57±5.84	50.52±7.04	49.48±7.33	49.54±5.39	50.11±11.83	65.66±0.00
Anterolateral	55.52±6.66	55.76±7.12	55.11±6.48	55.45±4.92	55.77±5.33	73.00±0.00

Table 13: Normative SEBT Values of Left Stance in Female with Different BMI

SEBT directions	<18.5 KG/M²	18.5-24.9KG/M²	25.0-29.9KG/M²	30-34.9KG/M²	35-39.9KG/M²	≥40KG/M²
	N = 54	N = 397	N = 90	N = 16	N = 3	N = 1
Anterior	56.27±6.82	56.69±7.45	57.39±7.30	56.18±3.68	53.22±1.34	70.66±0.00
Anteromedial	58.07±7.38	59.06±8.36	59.39±8.98	59.89±5.78	57.77±3.68	65.00±0.00
Medial	56.30±7.53	57.4±8.26	57.38±7.87	59.93±4.99	52.55±0.83	69.33±0.00
Posteromedial	51.94±8.36	53.35±8.87	53.89±8.49	54.37±5.54	48.55±5.17	65.66±0.00
Posterior	47.77±7.51	49.36±8.15	50.08±7.04	50.52±6.01	44.88±8.92	57.66±0.00
Posterolateral	47.08±7.56	48.04±8.49	48.11±7.83	48.10±7.23	42.88±6.84	59.66±0.00
Lateral	52.82±6.74	52.40±6.82	51.79±7.49	50.04±4.25	48.33±9.07	69.33±0.00
Anterolateral	56.23±6.70	56.40±7.11	56.06±7.11	54.37±5.05	53.11±2.21	73.66±0.00

Table 13 shows normative values for the Star Excursion Balance Test (SEBT) in left stance among female individuals categorized by different BMI ranges.

DISCUSSION

One of the most important steps in rehabilitation is to assess specific movement patterns to establish the possible risk of injury, as any inappropriate results can only be compared against normal findings. The SEBT valid and reliable promising postural control test that can be used not only to assess physical performance, but also to screen for deficits in dynamic postural control due to musculoskeletal disorders (e.g., chronic ankle instability), to identify athletes at higher risk for lower extremity injury, and to aid in the rehabilitation of orthopedic injuries in healthy active adults. Even though it is the most promising postural control test the normative values of SEBT are not established yet thus, the present study aims to elucidate the normative values of SEBT in healthy young adults.

In the present study total of 1000 individuals aged between 17 to 30 years were conveniently selected from different colleges in south Gujarat. Out of 1000 individuals, 239 were males which account for 23.9% of the total population, whereas 761 were females which account for 76.1% of the total population. The mean age of included males was 22.09 with a standard deviation of 3.02 years, whereas, the mean age of the females was 21.44 with a standard deviation of 2.04 years. The mean height of included males was 168.80 with a standard deviation of 9.63 cm, whereas the mean height of females was 157.75 with a standard deviation of 7.35 cm. The mean BMI of the included males was 22.28 with a standard deviation of 4.05 whereas, the mean BMI of females was 20.81 and standard deviation was 4.15.

In the present study, gender, height, and BMI-specific reference values for the SEBT were obtained in healthy young individuals. These gender, height, and BMI-specific reference values would improve the interpretation of the SEBT in routine clinical practice and provide reference values against which patient performance could be compared; additionally, these SEBT reference values could be used as reach targets during the progression of patient rehabilitation.

The SEBT excursion reach by males reveals that male have higher normalized excursion reach scores in all 8 directions of the SEBT as compared to females because males' height and leg length were considerably greater than females. These findings are correlated with study done by Egwu et al. [7], who state that females are commonly reported to have shorter legs than males, resulting in a reduction in SEBT excursion reach in females.

Another study done by Overstall P et al [8] which states that males had greater balance performance compare to women because postural sway rises with body weight. And in females most of the fat is concentrated in chest, thigh and trunk which shifted COG to weighted side. This changes in COG will leads to changes in LOG and BOS leads to increase postural sway thus leads to disequilibrium. When body weight is more than muscular mass, it fails to maintain equilibrium, leading in a shorter excursion reach distance.

The current study found that both males and females right lower limbs had a shorter reach distance in the posterolateral, lateral, and posterior directions, but the longest excursion reach in the anteromedial, anterior, and medial directions. The male and females left lower limb has a shorter excursion reach distance in the posterolateral, lateral, and posterior directions and the longest excursion reach distance in the anteromedial, anterior, and medial directions. These results can correlate with the study done by sarkar B et al [1]. In that study they found that man had reduced reach in posterior posterolateral and lateral direction through right and left leg and similarly found that they have greater reach in anterior, anteromedial and medial directions.

One possible reason for the reduced excursion reach distance in the posterolateral, lateral, and posterior directions is that the individuals received less visual feedback in these directions, particularly the posterior and posterolateral directions, increasing pressure on the somatosensory system and joints. This finding is supported by Coughlan et al [9], who discovered that in SEBT and Y-balance tests, the reach distance in posterolateral directions is decreased because visual awareness is reduced in the posterolateral directions, putting an increased demand on the somatosensory system and, as a result, participants' inability to see their scores may restrict their reach. In the anterior reach direction, participants got visual input from the reach leg as they moved and may view the scored reach distance on each trial, so the excursion distance in this direction are more.

The present study also reports that as the individual's heights will increase the reach distance in all directions were increased. This is due to direct correlation between the length of the lower limb and the reach distance and height of the person. This results strongly correlate with the study done by gribble et al. [5] shows that there is significant correlation found between person height, length of the lower limb and distance reach in particular directions.

The current study also found that SEBT excursion reach is greater in volunteers who are underweight or normal, but less in obese people. In obese individuals, greater torque falls on the lower extremities, reducing excursion reach, whereas in those with normal BMI, loading drops dramatically, increasing excursion reach. This conclusion is consistent with the findings of a research done by Delporto et al [10] on the biomechanical effects of fat on balance. They claimed that obese individuals had higher knee joint torque than normal people, when the opposite is true.

In this study, it was discovered that SEBT excursion reach scores were higher on the right side than on the left side because the right side was dominant in the majority of the individuals, resulting in a larger excursion distance. This finding was supported by Bahamonde R et al [11], who conducted a study on the effects of leg dominance on the single leg hop functional test in non-injured adults and discovered that subjects were able to jump significantly farther when using their dominant leg because the dominant leg produces more vertical and horizontal ground reaction forces than the non-dominant leg.

CONCLUSION

The current study effectively determined the normative values of SEBT based on gender, different height, and BMI categories. Our findings demonstrate that males have a longer average reach distance in all eight directions than females. It has also been shown that people who are normal and underweight have a greater reach distance than those who are overweight or obese. Individuals who were taller were shown to have a longer reach distance than shorter. The average distance is more on the right side compared on the left side due to leg dominance. Therefore, it is advised that physical therapists and doctors' analyses SEBT values in relation to the above-mentioned normative values, taking into account the impacts of height, BMI, and gender diversity.

LIMITATIONS OF THE STUDY

- Results cannot be generalised because all the patients were from south Gujarat.
- Bilateral leg length was not considered

FUTURE RECOMMENDATIONS

- Correlation between height, reach distance and BMI was established in future studies.

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DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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