# Effect of Flat Feet on Static and Dynamic Balance in Adults

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## Abstract

**Background:** The foot is the most distal segment in the lower extremity chain and represents a small BOS upon which the body maintains balance. Minor biomechanical alterations in the support surface can influence postural-control strategies. However, the implications of a flat foot on balance have received little attention to date.Aimof the present study was to Evaluate the static and dynamic balance in individuals with flat feet.

**Method:** A total of 40 subjects were recruited. Participants were assigned to 2 groups case group and control group depending on foot type, as defined by the foot ink print method. Subjects were divided into case groups and control groups. The static and dynamic balance were measured through the Unipedal stance test and star excursion balance test respectively.

There was a significant correlation between single-leg stance time (with eyes opened and closed) and flat feet (p-value = < .01). There was a significant correlation between reach distance in some direction (AM, MR, PM, P, AL, LL) with a flat foot (p-value <0 .05).

**Conclusion:** This study suggests that both static (single leg stance test) and dynamic (SEBT) balance are affected in individuals with flat feet.

***Keywords:*** *Pronated foot, foot structure, Balance.*

## Introduction

The foot is a terminal portion of a lower limb that bears weight and makes the human upright and performs activities like walking, running, and jumping. Feet enable ambulation with a bipedal gait and provide a static platform. Thisis due to the elastic arches or springs in the footknown as longitudinal arches. These are segmented in nature to sustain stress and thrusts. During a walking cycle, a normal foot changes from a supple to a rigid position while the concavity of the sole is maintained [1, 2].

The important characteristic of this arch is its elasticity, owing to its height and the number of small joints between its parts. Because of their elastic properties, these soft tissues can spread ground contact reaction forces over a longer period, and thus reduce the risk of musculoskeletal wear or damage. Any alteration in these arches can cause pronated and supinated foot which can alter the person's balance. [3, 4, 5]

Balance has often been used as a measure of lower extremity function and is defined as the process of maintaining the center of gravity within the body's base of support [6]. For control of body alignment and

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the center of gravity over the base of support in an upright stance, the central and peripheral components of the nervous system interact constantly. [7, 8]

Balance is maintained in the closed kinetic chain and relies on the integrated feedback and movement strategies among the hip and ankle. Hence, it can be disrupted by diminished afferent feedback or deficiencies in the strength and mechanical stability of any joint or structure along the lower extremity kinetic chain. Balance is often described as being either static or dynamic. [6]

Static balance is commonly assessed by instrumented measurements of ground reaction forces or non-instrumented means. static postural control can be assessed by having an individual attempt to maintain a stationary position while standing on either one or both feet. The common example of non instrumented static balance is an unipedal stance with eyes open and closed [9, 10, 6].

Dynamic balance often involves the completion of a functional task without compromising one's base of support. Numerous tests have been developed to assess the dynamic balance. The star excursion balance test is the most sensitive test for dynamic balance. [11]

Pes planus is a relatively common condition.The prevalence of flexible flatfoot is 21-57% in children at preschool [2] with its prevalence gradually declining to 15–20% in adulthood. In most cases, the pes planus is flexible, with the rigid form observed only in 1% [12].

Excessively pronated foot postures can affect somatosensory input via changes in joint mobility or surface contact area or, change in muscular strategies to maintain a stable base of support. Excessive pronation may place greater demands on the neuromuscular system to stabilize the foot and maintain an upright stance. So, Measurement of balance is an important tool in the assessment of foot dysfunction [1, 13, 14].

Poor foot position sense is thought to hinder accommodation between the plantar surface of the foot and support surface, thus requiring postural adjustments more proximally to maintain upright posture and balance. Although static and dynamic balance to be adversely affected by changes in peripheral input secondary to joint injury and changes in the stability of the surface on which one is standing, however, it is less explored whether subtle alterations in the surface, stability or peripheral input of the support foot can also have an effect on balance in those with different foot types. [15, 16]

Karen P. Cote et al. studied the effect of Pronated and Supinated Foot Postures on Static and Dynamic Postural Stability and found postural stability is affected by foot type under both static and dynamic conditions [15].Far less attention has been focused on whether more subtle alterations in the surface, stability or peripheral input of the support foot may also affect balance in those with different foot types.So the study aims to evaluate the static balance (with eyes opened and closed) and dynamic balance in flat feet.

## Methodology

It was an observational study with convenient sampling. Approval was obtained from the institutional research committee. Participants were recruited based on inclusion criteria. Inclusion criteria were age group from 20-50 years, both genders, subjects who diagnosed as flat foot, persons with the normal foot. Participants with H/o any musculoskeletal and neurological conditions affecting balance were excluded. written informed consent was obtained before the commencement of the study.

A total of 45 subjects was assessed by the ink footprint method in which they were made to stand in a pool full of ink water and were asked to step on a paper and the footprint was observed. In normal individuals, the medial portion of the foot was not visible but in individuals with a flat foot, the medial portion of the foot was completely visible. A total of 20 subjects out of 25 meeting inclusion criteria were included in the study.20 normal subjects with normal feet who were matched with the age and sex of the case group were recruited.

Subjects were assessed for static and dynamic balance tests using Single leg stanceand Star excursion balance test respectively.

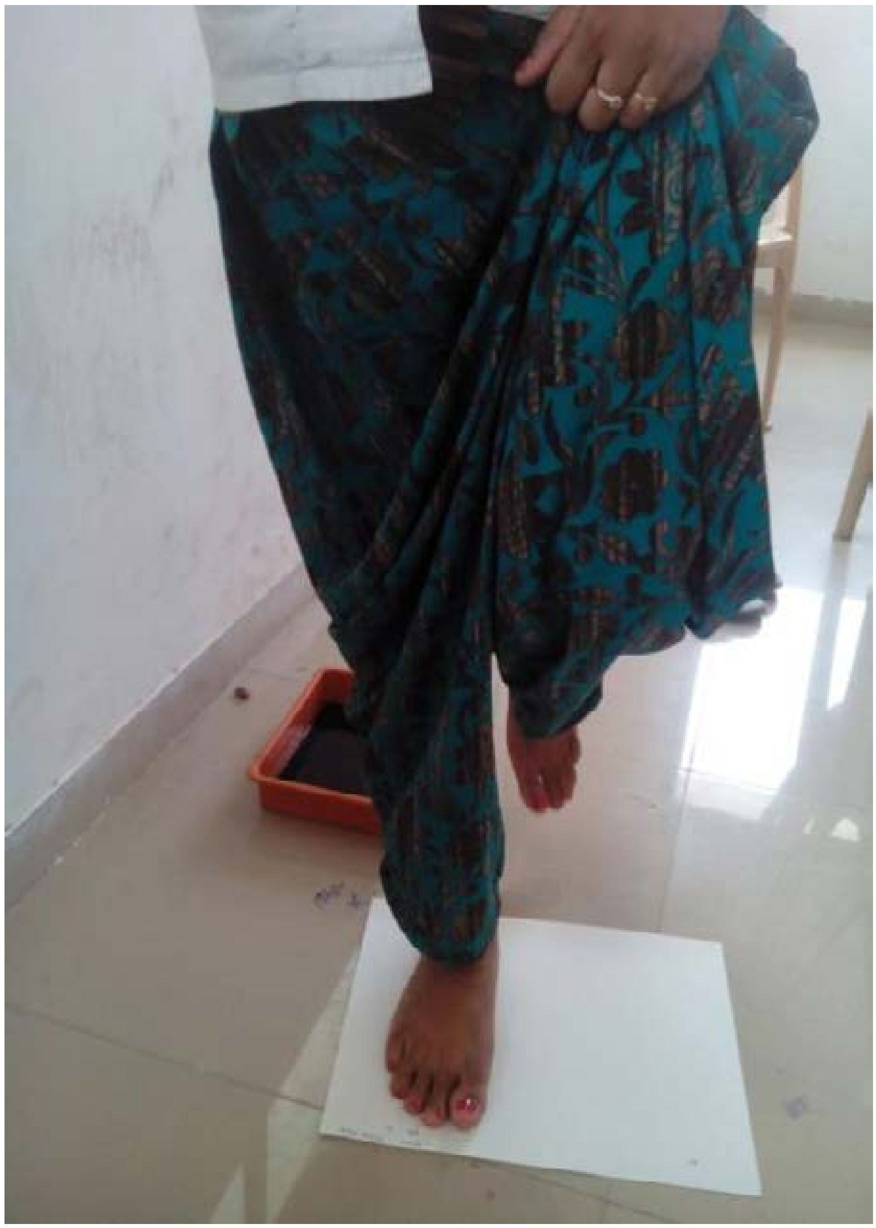


**Figure :1foot imprint ink method**

Static balance is assessed by a single leg stance test (with eye opened and with eye closed).[17] Star Excursion Balance Sheet was made on flex to measure dynamic balanceThe SEBT was performed with the subject standing in the middle of a grid on the flex poster placed on the floor with 8 lines extending at 45° increments from the center of the grid. The grid was constructed and enclosed in a 6-foot by 6-foot (1.83-m × 1.83-m) square on the flex poster. The 8 lines on the grid was named about the direction of reach concerning the stance leg: anterolateral (AL), anterior (A), anteromedial (AM), medial (M), posteromedial (PM), posterior (P), posterolateral (PL), and lateral (L).[18]

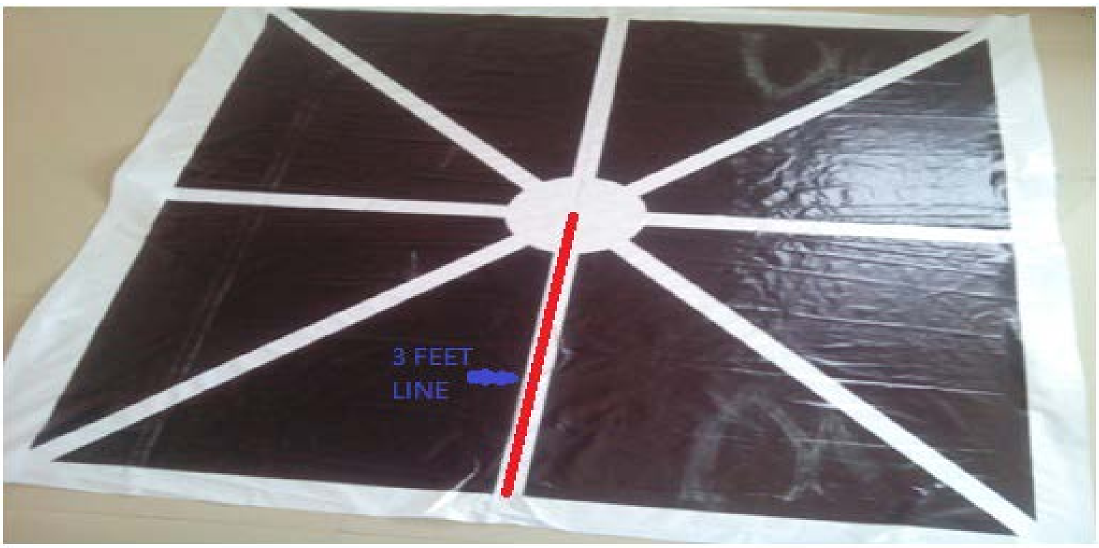
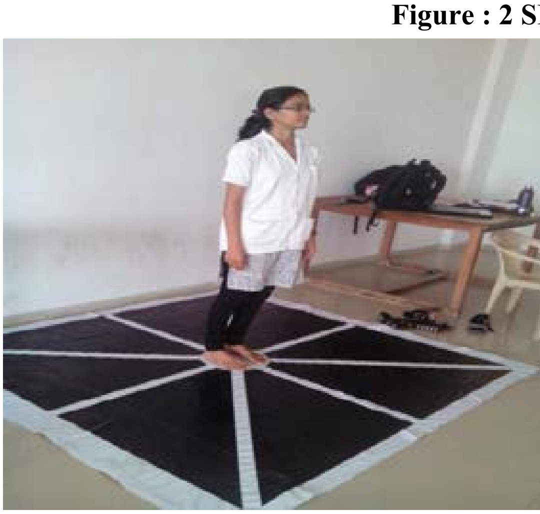



**Figure : 2 SEBT Flex**



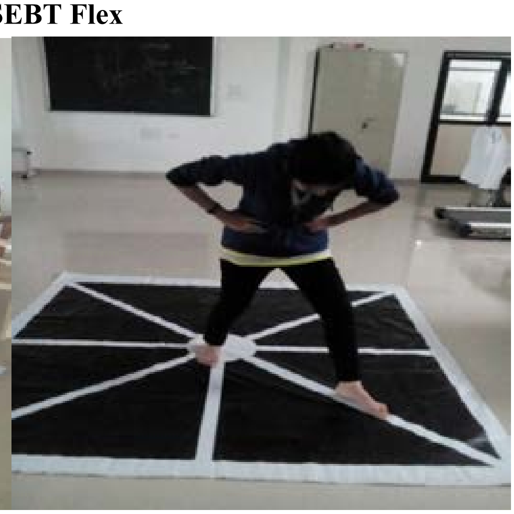


**Figure 3 :Starting Position Of SEBT Reach Figure 4:performance of the SEBT**

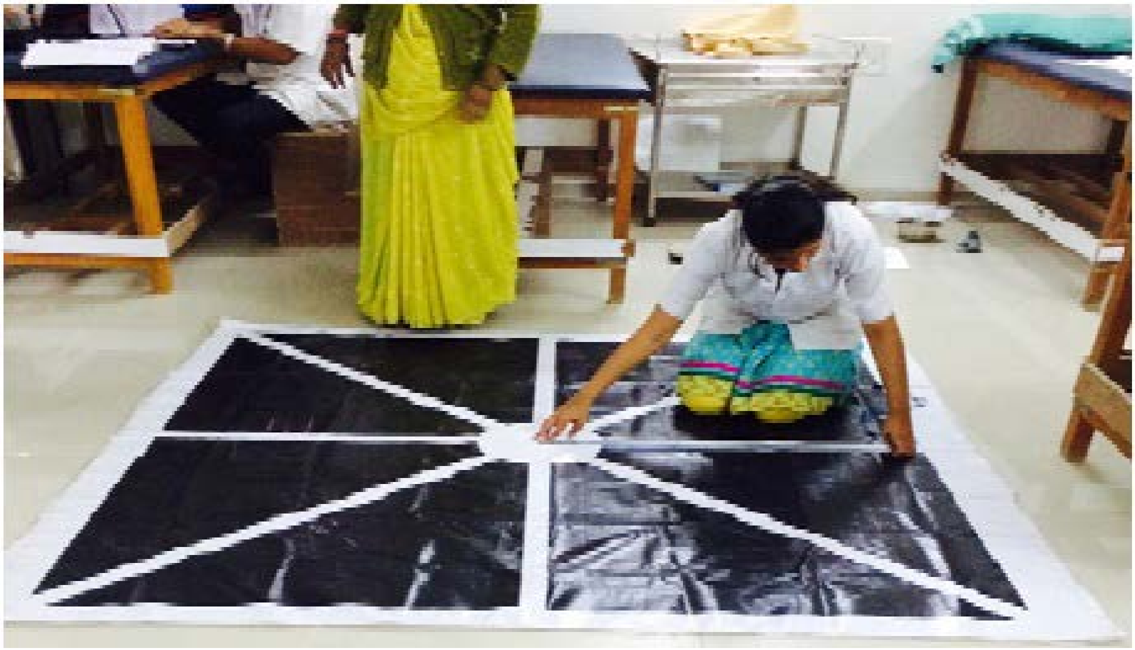


**Figure 5 :Measurement of Reach From The Centre Point Of The Grid To The Reach Distance**

Results of the tests were documented in MS Excel and were used for data analysis.

**Materials**:Measuring tape, Chalk, SEBT flex, Stopwatch, Ink, paper

## Statistical Analysis

Collected data were analyzed using SPSS 16 version software. Descriptive statistics including Mean, Standard Deviation (SD), and Confidence Interval (CI) were obtained

An Independent t-test was applied to check the difference in mean values of various parameters between case and control groups

An Independent t-test was applied to compare the static balance between case and control groups

An Independent t-test was applied to compare dynamic balance between case and control groups

**Table 1: Descriptive Statistics**

| | NORMAL | | FLAT FEET | | t-value | p-value |
|---|---|---|---|---|---|---|
| | MEAN | SD | MEAN | SD | | |
| Age | 26.40 | 7.49 | 26.65 | 9.89 | -.090 | .929 |
| Weight | 55.50 | 10.03 | 59.15 | 9.91 | -1.157 | .254 |
| Height | 158.90 | 6.57 | 159.65 | 6.17 | -.372 | .712 |
| BMI | 22.20 | 4.21 | 22.99 | 3.65 | -.628 | .534 |

The mean value of demographic data was not significantly different between the two groups.

**Table 2: Shows Correlation of USPT Time (sec) (with eye opened and closed)**

| | Normal | | Flat feet | | t-value | p-value |
|---|---|---|---|---|---|---|
| | MEAN | SD | MEAN | SD | | |
| EOR | 12.56 | 2.14 | 5.75 | 1.96 | 10.18 | .00 |
| ECR | 5.263 | 1.37 | 2.73 | .50 | 7.36 | .00 |
| EOL | 10.396 | 2.11 | 5.46 | 3.37 | 5.54 | .00 |
| ECL | 4.876 | 1.60 | 2.33 | .76 | 6.39 | .00 |

**[ EOR= eye opened right side, ECR= eye closed right side.,EOL= eye opened left side, ECL= eye closed left side]**

The mean value of USPT test time with an eye opened and closed in both the legs was significantly more in the case compared to control groups [p value < 0.01]

**Table 3.1**: **Shows Comparison of SEBT Distances in (Lt) Leg Between Two Groups**

| The direction of the reach | NORMAL (n=20) | | FLAT FEET (n=20) | | t-value | p-value |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | |
| A | 81.77 | 4.40 | 80.80 | 5.94 | .58 | .56 |
| AM | 80.59 | 7.90 | 75.59 | 7.68 | 2.02 | .04 |
| MR | 66.18 | 9.01 | 59.82 | 10.64 | 2.04 | .04 |
| PM | 65.88 | 7.89 | 85.47 | 108.29 | -.80 | .42 |
| P | 63.54 | 5.98 | 61.79 | 8.39 | .76 | .45 |
| PL | 71.30 | 6.00 | 66.42 | 8.53 | 2.09 | .04 |
| LL | 74.69 | 4.47 | 71.09 | 7.00 | 1.93 | .06 |
| AL | 85.77 | 7.03 | 81.42 | 6.93 | 1.96 | .05 |

**[A= anterior, AM= anteriomedial, MR= medial right, PM= posteriomedial,**

**P= posterior, PL= posteriorlateral, LL = lateral left, AL= anteriolateral ]**

The mean value of AM, MR, PL, AL direction reach distance with (Lt) leg was significantly different between case and control groups.

The mean value of A, AM, P, LL direction reach distances with (Lt) leg was not significantly different between case and control groups reach.

**Table 3.2: Shows comparison of SEBT distances in (Rt) leg between groups**

| The direction of the reach | NORMAL N=20 | | FLAT FEET N=18 | | t-value | p-value |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | |
| A | 82.09 | 3.96 | 81.78 | 5.35 | .20 | 0.836 |
| AM | 85.93 | 9.25 | 83.20 | 6.91 | 1.02 | 0.314 |
| MR | 76.01 | 4.50 | 73.84 | 5.64 | 1.31 | 0.197 |
| PM | 73.63 | 7.10 | 68.73 | 10.09 | 1.74 | 0.090 |
| P | 66.02 | 7.22 | 61.32 | 8.60 | 1.82 | 0.076 |
| PL | 65.730 | 8.01 | 91.15 | 132.76 | -.85 | 0.398 |
| LL | 64.0045 | 7.79 | 58.10 | 10.46 | 1.98 | 0.055 |
| AL | 80.4965 | 8.00 | 72.50 | 8.07 | 3.05 | 0.004 |

[A=anterior, AM=anteriomedial, MR=medial right, PM=posteriomedial, P=posterior, PL=posteriorlateral, LL = lateral left, AL= anteriolateral]

The mean value of LL, AL direction reach distance with (Rt) leg was significantly different between case and control group.

Mean value of A, AM.MR.PM, P, PL reach distances with (Rt) leg was not significantly different between case and control groups.

## Discussion

The result of the present study shows the significant difference between two groups for static balance with single leg support however for the dynamic balance test reach distance for AM, M, PL, AL, and LL were significantly different between the groups. A total of 40 subjects were recruited in the study and equally divided into two groups, 20 patients in case and 20 subjects in the control group.

Statistically, no difference has been found between the groups about age, gender, BMI, and height. In the present study flat feet were found to be more common in females, out of 20 patients in the case group 17 were females and 5 were males. Hassan Daneshmandi, Nader Rahnema et al. (2009) studied "Relationship between Obesity and Flatfoot in High-school Boys and Girls" and concluded that increasing weight temporarily, may cause the existence of significant difference in the prevalence of flatfoot among high-school boys and girls. [19].

In the present study Single leg stance test(with eyes opened and closed) was used to check static balance.[20]. The mean USPT time (sec) (with eye opened and eye closed position) (p-value =<01) was found to be significantly higher in the case compared to the control group.

This is due to Proprioceptive feedback during joint motion depends not only on sensory information from joint receptors (ie, ligament and capsule) but also includes divergent information from skin, articular, and muscle mechanoreceptors. [21].

Increasing the rear angle leads to an increase in the angle of heel valgus, which leads to balance disruption. Change in the alignment of the heels, which is the junction of the muscles and ligaments of the foot leads to change in the muscle stretch angles and inactive elements around joints. This leads to incorrect messages from the foot to the central nervous system, which can in turn affect the balance. Moreover, the development of heel valgus results in limited contact of the heel with the ground surface; therefore, fewer sensory receptors participate in sending necessary information to maintain balance. [22]

A similar study was conducted by Mohammad Taghi Karimi (2013) on "Evaluation of standing stability in the individual with flat feet" and suggested that individuals with the flat foot are more unstable when compared with normal individuals during quiet standing [23]. Karen P. Cote et al in 2005 studied "Effects of Pronated and Supinated Foot Postures on Static and Dynamic Postural Stability" concluded that some aspects of postural stability are affected by foot type, but we believe structural stability, rather than altered proprioception,is likely the basis for our results [15].

The purpose of using SEBT in the present study was to identify dynamic balance deficits in patients with a variety of lower extremity conditions. During the study height and leg length were statistically adjusted with a reach distance. Results for mean normal values of the reach distance in 8 directions were comparable to those values obtained by Phillip A. Gribble and Jay Hertel in 2003.[11] A significant correlation ($p < .05$) was found between height and excursion distance, and leg length and excursion ($p <$ .05) distance in six of the eight directions [9].

Results for SEBT revealed that only certain reach directions were affected in the case group.There was a significant reduction in 6 reach direction (AM ,MR,PL,AL,LL (p-value = < .05) in case group . Both the groups reached similar distances in the A and P directions.

Karen P. Cote et al (2005) studied Effects of Pronated and Supinated Foot Postures on Static and Dynamic Postural Stability and revealed that only certain reach directions in SEBT were affected by foot type. Postural stability is affected by foot type under both static and dynamic conditions [9].

Reduced distance in an oblique and lateral direction in flat foot patients might be due to excessive pronators tend to collapse toward the medial aspect of the foot and have a reduced ability to maintain rigid support in full weight-bearing. This medial deviation and greater foot mobility may account for pronators and reduce dynamic reach in the lateral direction. It requires more muscle strength, neuromuscular control, and more accurate proprioception in the lower extremity joints to maintain dynamic balance [9].

A recent study by Olmsted et al revealed that reach distance on the SEBT was significantly less in individuals with chronic ankle instability and different foot type than in normal individuals, these results were found across all reach directions and were not direction-dependent. In contrast, we found differences in only certain directions in pronated feet [16].

## Conclusion

Both static and dynamic balance is affected in individuals with flatfoot as compared to individuals with a normal foot. In subjects with a flat foot, the meantime was lesser than subjects with a normal foot. SEBT is affected in flat feet specifically in AM, MR, PL, AL, LL directions.

**Limitations**

1. The majority of flat feet subjects were between 20-30 years of age.

2. Few males with flat feet as compared to the number of females subjects.

3. Assessment of confirmation of flat feet was done by ink print method which is dichotomous. No objective method was used to assess the degree of flat foot.

**Ethical Clearance-** The Ethical Approval was taken from Sumandeep Vidyapeeth Institutional ethical committee.(SV1EC/ON/PHY/BNMPH3/D15009)

**Source of Funding-** Self

**Conflict of Interest**-Nil

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