# VALIDITY OF A SMARTPHONE APPLICATION IN ASSESSING BALANCE IN PATIENTS WITH CHRONIC ANKLE INSTABILITY

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## Abstract:

**Background:** Lateral ankle sprain is a common injury,with an incidence of 7 per 1000 exposures. Sprain may persist leading to chronic ankle instability (CAI), which is believed to arise from dysfunctional postural control, defective proprioception, muscleweakness, or reduced ankle range of motion. Thus, assessment of postural control is essential for proper clinical decision-making and treatment selection.With advances in technology, smartphone has been usedto assess the musculoskeletal system. Ithas the advantages of being portable and economic. Yet, further validation is needed to allow its use in clinical settings. Therefore, the purpose of this study was to assess the concurrent validity of a smartphone application in assessing balance in patients with CAI. **Methods**: Twenty-four participants; 10 patients (14 ankles with CAI)and 14 healthy volunteers(28 ankles) were enrolled in this study. Alltesting procedures were conducted in accordance to and approved by the local ethics committee.Balance was measured during single leg stance (with eyes opened and closed)simultaneously by the smartphone application "MyAnkle" and the Biodex balance system. Testing was done bilaterally in a random order. All data were collected by an assessor who was blind to participants' grouping and limb condition. To establish validity, Spearman's rank correlation coefficients was used to test the associationbetween the application score and the overall stability index of the Biodex system. **Results**: For patients group, the correlation between measurements done by the two devices was insignificant weak for both limbs in both eye conditions (opened and closed).For healthy volunteers, the dominant limb showed significant correlation when the eyes were closed ($r = 0.56$, $p = 0.037$), however, the relation was insignificant and weak for the eye-opened condition and for non-dominant limb in the two eye conditions ($r<0.5$, $p>0.05$). **Conclusion**: With the available number, the smartphone application is not valid compared to the Biodex system in assessing balance in patients with CAI. For healthy volunteers, validity is dependent on eye-condition andlimb dominance.

**Key words**: validity, balance, smartphone

**Introduction:**

Lateral ankle sprain (LAS) is a common injury in athletic and regular activities; with an incidence of 7 per 1000 exposures.[1,2,4–6]It has a high recurrence rate that ranges from 20 to 78%.[7,8]LAS symptoms may persist leading to chronic ankle instability (CAI).[8] This instability is believed to arise from dysfunctional postural control, defective proprioception, muscle weakness, or reduced ankle range of motion(ROM).[1–3]Eventually, chronic instabilityresults in impaired physical activity, altered hip and ankle biomechanics as well as changes in landing pattern and in postural control.[9–11]

Thus, assessment of postural control is essential for proper clinical decision-making and treatment selection. There are many subjective and objective methods to assess postural control.[12]Subjective methods include single leg stance and balance error scoring system. These are easy, inexpensive and clinically feasible methods. However, they are limited by the lack of quantitative measurement and their reliance on investigator's skill and experience.[3,13]

Objective methods include the Biodex balance system andstar excursion balance test (SEBT). Biodex balance system is a device that assesses postural control by determining the ability of a participant to maintain balance on an unstable surface.[14]It is an objective, reliable and valid device (1CC= 0.64 - 0.89) that provides quantitative data.[12,15]Yet, it is expensive and large in size, thus, it is difficult to accommodate in regular clinical settings.[12]SEBT is a popular test that is used both in clinical and research settingsto assessdefective postural control during dynamic movement.[16,17]SEBT has a high reliability and validity(ICC= 0.84 - 0.87).[18] Further, itis inexpensive and a time-efficienttool.[16,18,19]However, test results may be affected by the strength and flexibility of lower limb muscles.[18]Therefore, there is a need for

alternative postural control assessment method, especially the balance component, that combines the advantages of subjective and objective measures and overcomes their disadvantages. This method should be valid, reliable, easy to administrate, inexpensive, feasible and portable, if possible.

With advances in technology, smartphone has been introduced as an assessment tool for the musculoskeletal system. For example, it was used to assess ROM, mobility, balance and risk of falling in stroke survivors and frail elderly.[20–23] Further, it was used to assess balance in healthy and participants with chronic ankle sprain, however, the results were not compared to gold standard methods.[3,12,24]Thus, the aim of this study was to investigate the concurrent validity of a smartphone application in assessing balance in patients with CAI.

## Material and methods:

### *Study design*

This is a cross-sectional study that was conducted between July and December, 2018 at the Biodex Balance System laboratory, Faculty of Physical Therapy, Cairo University, Egypt. The protocol for this study was approved by the Ethics committee of the Faculty of Physical Therapy, Cairo University, Egypt.

### *Participants*

Ten patients(14 ankles with CAI and 6 normal ankles) and 14healthy gender-, Body mass index (BMI) and age-matched volunteers(28 normal ankles)were enrolled in this study. Patients with CAI were recruited from the outpatient clinic of the faculty of Physical Therapy and faculty ofMedicine, Cairo University, based onthe followingcriteria: age ranging between 18 and 35 years old,[3,12,24] referred with a

confirmed diagnosis of unilateral or bilateral CAI, has a Cumberland Ankle Instability tool score lower than 27 points,[3]and had a recurrent sprain within the previous year.[25]Patients were excluded if they had history of major surgery of lower limb or spine [17], lower extremity fracturewithin the past two years,[17]orlower limb injury 3 months prior to study[3]. Further, patients were excluded if they reportedbalance deficit due to visual or vestibular deficits, neurologic disease, or cerebral concussions during the past 3 months.[17,25] Moreover, patients were excluded if they were receiving balance training program,[25]or they had weakness of lower limb musculatures based on thescreening muscle testing performed by the investigator.Healthy asymptomatic participants were recruited from the students of the Faculty of Physical Therapy, Cairo University, Egypt.

***Measurement procedures***

Recruited individuals were initially screened against study inclusion and exclusion criteria. Then, eligible subjects had the aim of study and all testing procedures verbally explained and all relevant questions answered. If they agreed to participate in the study, an informed consent was signed.Then, basic demographic data were collected. This was followed by a screening lower extremitymuscle test.

Before testing, the Biodex system and the smartphone were calibrated according to manufacturer'sand developers' guidelines.[24]Then, validation was tested in a single session, during which balance was simultaneously measured by the smartphone "MyAnkle" application and the Biodex balance system.Both limbs were tested at a random order generated by the Excel software.

Patients were then asked to stand on the Biodex platform while it was locked. Feet position on the platform and patient's basic demographics were also entered into

the Biodex balance system software. The smartphone was secured above the superior midline of the patella using an adjustable armband. Afterwards, the platform was released and the application was initiated. Patients were tested usinga single leg stance protocol on the Biodex system at level 8. Participants were asked to maintain hands on hips duringtesting [26]and not to touch the ground or stance limb by the other limb or not to grasp the handrail,yet touching handrail was allowed to prevent falling. If any of the previous compensatory motions were done, the test was terminated.

A single-leg stance testing was then done at two eye conditions: (1) opened eyes for 30 seconds, and (2) closed eyes for 10 seconds.During the testing, eachparticipant was asked to keep the cursor on the Biodex screen in the middle while the platform was moving. The researcher stood beside the participant and secured him/her by both hands to protect against falling.Participants were allowed 2-minute rest between the testing of the right and left legs. All smartphone application data were collected by an assessor who was blinded to participants' grouping and limb condition.

***Data analysis***

All data were collected and tabulated in an excel sheet. Then, theywere screened for normality assumption by Kolmogorov-Smirnov and Shapiro-Wilks normality tests.Descriptive statistics were presented as means and standard deviations. Further, Spearman's rank correlation coefficients (ρ) were calculated to examine the association between the balance score of the application and the overall stability index of the Biodex for both eye-conditions and limb sides. The level of significance was set at $p<0.05$.The correlation results were interpreted as poor ($r < 0.30$), low ($r s = 0.30$ to 0.50), moderate ($r = 0.50$ to 0.70), high ($r = 0.70$ to 0.90), or very high ($r >$

0.90).[27]All statistical testes were done using SPSS version 18 (IBM Inc., Chicago, IL, USA).

**Results:**

Age, weight, heightand BMI were not significantlydifferent between patients and healthy groups($p>0.05$, Table 1).

**Table 1-descriptive statistics of age, weight, height and BMI in the CAI and healthy group**

| Variable | CAI Mean±SD | Healthy Mean±SD | P-value |
|---|---|---|---|
| Age (years) | 23.40±1.89 | 23.57±2.60 | 1 |
| Weight (Kg) | 63.30±13.6 | 62.64±11.33 | 0.93 |
| Height (cm) | 160.00±8.32 | 162.64±10.68 | 0.66 |
| BMI($Kg/cm^2$) | 24.51±3.58 | 23.54±2.33 | 0.40 |

BMI: Body Mass Index; CAI: Chronic Ankle Instability; SD: standard Deviation

In patients with CAI, no significant correlations were found between the application balance score and the overall stability index of the Biodexon both the affected and non-affected limbs, while eyes were opened and closed ($p>0.05$, Table 2).

In the healthy group, the dominant limb showed significantpositive correlation when the eyes were closed($p = 0.04$). However, this correlation was not significant when eyes were opened ($p>0.05$, Table 2). For the non-dominant limb, no significant correlations were found inboth eye conditions ($P > 0.05$, Table 2).

**Table 2-Spearman's correlation coefficientof balance score between the "MyAnkle" application and the overall stability inex of the Biodex in patient and healthy control groups**

| Group condition | | Opened eyes<br>R (p-value) | Closed eyes<br>R (p-value) |
|---|---|---|---|
| Patients | Affected | -.012 (0.97) | 0.183 (0.53) |
| | Unaffected | -0.03 (0.96) | -0.73 (0.10) |
| Healthy | Dominant | 0.346 (0.23) | **0.561* (0.04)** |
| | Non-dominant | 0.133 (0.65) | 0.458 (0.10) |

∗Correlation is significant at the 0.05 level (2-tailed),CAI: Chronic Ankle Instability, P; probability, r; correlation coefficient between smartphone and Biodex

**Discussion:**

The purpose of this study was to investigate the concurrent validity of a smartphone application "MyAnkle" in assessing balance in patients with CAI and healthy volunteers.Only the dominant leg of healthy participants showed a significant correlation when the eyes were closed. No other significant correlations were found. This implies that there is no evidence to support the validity of smartphone in assessing balance in patients with ankle sprain. Further, smartphone validity in healthy adults is dependent on limb dominance and eye condition.

Thelack of validity inthe patient group could be attributed to increased postural sway due to increased reaction time of dorsiflexors muscles duringsingle stance, especially when eyes are blindfolded. Increased postural sway would result in increasedlimb acceleration in different planes. As smartphone measurements are affected by movement of the limb in all planes, whereas the Biodex measures only changes in centre of pressure in anteroposreior and mediolateral directions, the two devices will be measuring different values.[28,29]

On the other hand, the validity of smartphone in assessing the dominant limb of healthy volunteers with closed eyes could be attributed to the strong musculatures of this limb. With the absence of exteroception feedback from eyes, muscles are capable of steading the limb during perturbation turning it into a strut. Such steadying action would decrease limb movement; which the smartphone records. Hence, patient leg and the smartphone, will tilt together similarly to the platform of the Biodex.[30] When eyes come into play, they provide instantaneous feedback and minimize subjective feeling of insecurity or falling risk. This in turn will preventthe person from maximally activating limb muscles to steady the limb. Thus, limb acceleration may increase, resulting in thelimb no longer moving similarly to the Biodex platformgiving different readings for the two devices. This could also be true for non-dominant limb, where muscle strength is no adequate to minimize postural sway and limb acceleration.Thus, the limb is not necessary movingin the same direction as the platform.[31–33]

Thisis the first study that validated the smartphone application "MyAnkle" against gold standard and assessed balance for patient and healthy volunteers. However, a few limitations exist: first, phone was placed just above the thigh; other placements should be tested to ensure the best accurate placement to use.Second,

smartphone may not be sensitive to compensatory trunk movement associated with postural sway.

**Conclusion:**

There is no evidence to support smartphone validity"MyAnkle" in assessing balance in patients with chronic ankle instability. On the other hand, it is valid in assessing single-limb balance of the dominant side in healthy volunteers when the eyes are closed.

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**مصداقية و موثوقية الهاتف الذكى فى تقييم التوازن لمرضى عدم الاتزان المزمن بالكاحل**

**خلفية:**التواء الكاحل الجانبي هو إصابة شائعة مع حدوث ٧ لكل ١٠٠٠ من نسبة التعرض. قد يستمر الالتواء مما يؤدي إلى عدم استقرار الكاحل المزمن. اعتقد أن عدم الاستقرار ينشأ عن ضعف التحكم الوظيفي أو عجز الحس العميق أو ضعف العضلات أو تقليل حركة الكاحل.وبالتالي ، فإن تقييم الاتزان أمر ضروري لاتخاذ القرار السليم واختيار العلاج. مع التقدم التكنولوجي، تم إدخال الهاتف الذكي كأداة تقييم للنظام العضلي الهيكلي والذى يعد جهاز متنقل واقتصادي.ومع ذلك ، فإن تعميم استخدامه في الإعدادات المهنية يحتاج إلى مزيد من التحقق من مصداقية واختبار الخصائص النفسية.ولذلك كان الغرض من هذه الدراسة هو تقييم المصداقية المتزامنة لتطبيق الهاتف الذكي في تقييم التوازن لمرضى الاتزان المزمن بالكاحل.

**الطريقة:**تم تسجيل أربعة وعشرون شخص (١٤ شخصا أصحاء و ١٠ مرضى مع ١٤ أطراف يعاني من عدم الاتزان المزمن) في هذه الدراسة.تم إجراء اختبار تم اعتماده من قبل لجنة الأخلاقيات المحلية ، وتم قياس التوازن في الوقت نفسه عن طريق الهاتف الذكي وجهاز التوازن بيودكس.

ولا ، تم تأمين الهاتف الذكي فوق خط الوسط العلوي للرضفة باستخدام شارة قابلة للتعديل. بعد ذلك ، تم تدريب المريض وتدريبه على تنفيذ بروتوكول الوقوف على رجل واحدة على جهاز الاتزان بيودكس في المستوى ٨.بعد ذلك تم إجراء الاختبار مرتين: (١) الوقوف على رجل واحدة لمدة ٣٠ ثانية مع فتح العين ، (٢) و العين مغلقة و الوقوف على رجل واحدة لمدة ١٠ ثوانى مع غلق العين. تم اختبار كلا الطرفين بترتيب عشوائي. تم جمع جميع البيانات من قِبل مقيم خارجى ليس على دراية بحالة المشاركين وأطرافهم.

اختبار الصلاحية ، تم ربط درجة التوازن للتطبيق ومؤشر الثبات الكلي للبيودكس باستخدام معاملات ارتباط رتبة سبيرمان.

**النتائج:**بالنسة للاشخاص السليمة; أظهر الطرف الأيمن وجود ارتباط معنوي عند إغلاق العينين. بينما جميع الارتباطات الأخرى ضعيفة وغير ذات دلالة.

**الخلاصة:**مع العدد المتوفر ، تطبيق الهاتف الذكي غير صالح مقارنة بنظام الاتزان بيودكس في تقييم التوازن لمرضى عدم الاتزان المزمن بالكاحل.
للمتطوعين الأصحاء ، تعتمد الصلاحية على حالة العين والطرف المسيطر.