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Reliability of the ProKin Type B line system (TechnoBody™) balance system

Internal Project Report

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Introduction

Proprioceptive training is an integral element in the rehabilitation of the lower extremity following injury with the aim to improve the postural stability (Zech et al. 2010). Postural stability and balance has been defined as the ability to maintain the centre of body mass (COP) over the base of support (Mattacola et al. 1995). In a clinical routine it is important to control the effectiveness of a rehabilitation or training process in athletes or patients. This should be tested using reliable measurement devices. The primary function of a stability test is to understand and quantify how subjects globally manage instability.

Proprioceptive control in a static position (stabilometry) is often altered in dynamic situations. However, most of the postural stability is evaluated in static test conditions. Turbanski et al. 2010 question the use of static tests in order to predict the athlete's behaviour in dynamic situations accompanied with an increased injury risk and claim for dynamic test conditions. There are various measures and devices on the market to assess the ability to maintain postural stability. The Pro-Kin Type B line system (Techno-Body™) is used to assess the postural stability in a static or dynamic double or single-legged situation. The platform stability is provided via an electro-hydraulic system driven by two stepper motors. Furthermore, it allows assessing the variation of the trunk using an angle inclination measure fixed on the sternum of the persons. This measure enables differentiating between the upper body and lower body movement. As it is a relatively new instrument there is little information about its reliability. Additionally, there is very rare information about the within-subject variability in performing a one-legged standing task in a dynamic situation. Reliability is determined as the variation between measurements of the same quantity on the same individual. To quantify this variation repeated measurements of the same individuals are needed in both intra-session (within the same test day) and inter-session (between test days) conditions. The purpose of this study was to quantify the reliability of the Pro-Kin (TechnoBody™) stability system used for a single-legged standing task on an instable platform.

Methods

Experimental Approach to the Problem

To assess both, the within-subject variability as well as the intra- and inter-session variability repeated measures were conducted on three test sessions. The first and second session were completed on day 1 with at least a 30min break in between (intra-day sessions). The third session was done on day 2 with a time-lag of 4-7 days in between. All sessions included 3 trials. Each trial was done in a one-legged stance position on an instable platform condition (Level 10). This was done on the dominant leg. The postural sway was quantified by the following outcome variables: perimeter (total covered distance of

COP [mm]), elliptical area (total area, which is circumscribed by the COP [mm^2]) (Figure 1 left) as well as the total trunk deviation (°) (Figure 1 right).

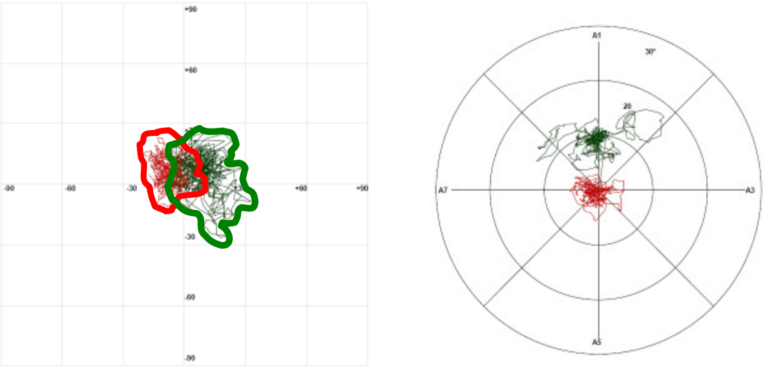

Figure 1: Center of Pressure (COP) Line: Perimeter (mm), Ellipse (mm^2)(left), Trunk SD (°) (right)

Subjects

Twenty-seven physical active persons at the age of 20-34 years (8 male, 19 female) were recruited for the study. The characteristics of the subjects are shown in Table 1. None of them had any injuries or disorders, which could influence a balance task. All subjects gave written informed consent before starting the study.

Table 1: Characteristics of the subjects

	Men (n=8)	Women (n=19)	Total (n=27)
Mean (±SD) age (y)	24.38 ±3.0	24.11 ±4.2	24.19 ±3.8
Age range (y)	22-31	20-34	20-34
Height (cm)	185.0 ±5.7	166.90 ±5.4	172.26 ±10.0
Mass (kg)	80.13 ±6.8	60.37 ±6.7	66.22 ±11.3
Activities (h/week)	13.1 ±3.8	7.6 ±5.0	9.3 ±5.2
Footedness (l/r)	2/6	1/18	3/24

Procedures

First of all, the dominant leg was determined using the lateral preference inventory (Coren 1993). This leg was used for testing. Before testing all participants underwent a 5min warm-up including skippings and plyometrics. For testing, a trunk sensor was placed over the sternum of the participant (Figure 2 left). Then the dominant leg was positioned on the platform. The foot's longitudinal axis was defined by a tangent determined by the third toe and the centre of the heel. This axis was aligned to the platform's y-axis (vertical line). Additionally, the medial malleolus of the foot was set to the x-axis (horizontal line) of the platform (Figure 2 right).

Figure 2: Trunk sensor position (left) and foot alignment on the platform (right)

The position of the supporting leg had a knee flexion of 30°, whereas the other leg was bent by 45°. The hands were fixed on the hips and the participants had to focus on a symbol approx. 1m ahead on eye level. The instruction for the subjects was to stand as stable as possible. The first session started with one 30 sec test trial before the three valid trials over 30 seconds were recorded. In between each trial the participants had a 1 min break. The first session was followed by a 30min break before starting the second session. After that the persons had a rest of 4-7 days. The inter-day sessions were performed at the same time of day. All tests were performed barefoot with open eyes to allow for visual control.
The tests were performed on the Pro-kin Line-B platform, using the test mode stabilometry test in an instable position (level 10). The observed variables were calculated by the implemented software (Prokin bipodalic, Version 4.7.6).

Statistics

First, absolute within-subject reliability was quantified using the coefficient of variation as well as the Root Mean Square Error (RMSE). This was done for all sessions separately. For the RMSE, it is assumed that the difference between two measurements for the same subject is expected to be less than 2.77 x RMSE for 95% of pairs of observations. Second, the mean of the three testing trials of each session was used to quantify the intra- and inter-day reliability. Paired t-test was applied to assess the differences between the sessions, respectively. Additionally, Bland-Altman-Plots were applied to illustrate the agreement between test-retest values. Therefore the averaged values of the intra- und interday sessions were plotted against their differences. These plots give information of a systematic bias and random error showing the direction and magnitude of the scatter around the zero line. Therefore the standard deviations of the differences are multiplied by 1.96 to obtain the 95% error component (limits of agreement). It is recommended that 95% of the data points should lie within these limits of agreement. All analyses were performed using SPSS 16.0.

Results

The CVs range from 32%-35% for the perimeter and from 39%-46% for the ellipse. The trunk deviation shows the highest coefficients ranging from 55% to 79%. The intra-subject variability is quantified using the RMSE (sw). The RMSE shows variations dependent on the respective session. The lowest RMSE values are displayed in session 2, for perimeter and ellipse, respectively. Hereby the repeatability for the perimeter is 266.28 mm, and for the ellipse 252.26 mm^2. For the trunk, the lowest RMSE is displayed in the third session with 11.77° (Table 2).

Table 2: Intra-subject variability (Mean ±SD, RMSE)

		Mean (±SD)	CV (%)	RMSE (sw)	Repeatability (2.77 x sw)
Perimeter (mm)	Session 1	1067.3 ±371.04	34.8	114.22	316.39
	Session 2	932.5 ±329.87	35.4	96.13	266.28
	Session 3	982.6 ±314.43	32.0	123.85	343.06
Ellipse (mm^2)	Session 1	418.1 ±171.34	41.0	120.41	333.54
	Session 2	357.6 ±139.32	39.0	91.07	252.26
	Session 3	359.5 ±163.55	45.5	107.57	297.97
Trunk (°)	Session 1	5.98 ±3.26	54.5	4.49	12.44
	Session 2	5.38 ±4.22	78.4	4.25	11.77
	Session 3	5.54 ±4.40	79.4	3.62	10.03

There are significant differences for the perimeter and the ellipse, both for intra-session as well as inter-session variations (Table 3). For the trunk, there are no significant differences between the test sessions.

*Table 3: Intra- and Intersession differences (** sign. (<0.01), * sign. (<0.05))*

	Intra-session (S1-S2) Difference (Mean ±SD)	p-value	Inter-session (S1-S3) Difference (Mean ±SD)	p-value
Perimeter (mm)	134.85 ±154.51 (**)	< 0.01	84.79 ±201.43 (*)	= 0.038
Ellipse (mm^2)	60.49 ±140.97 (*)	= 0.035	58.60 ±134.99 (*)	= 0.033
Trunk (°)	0.60 ±3.75 (n. s.)	= 0.413	0.44 ±5.08 (n. s.)	= 0.656

For all variables, but especially for the perimeter the inter-session differences are smaller compared to the intra-session differences. Figure 3 illustrates the agreement of intra- and intersession measurements for the three variables.

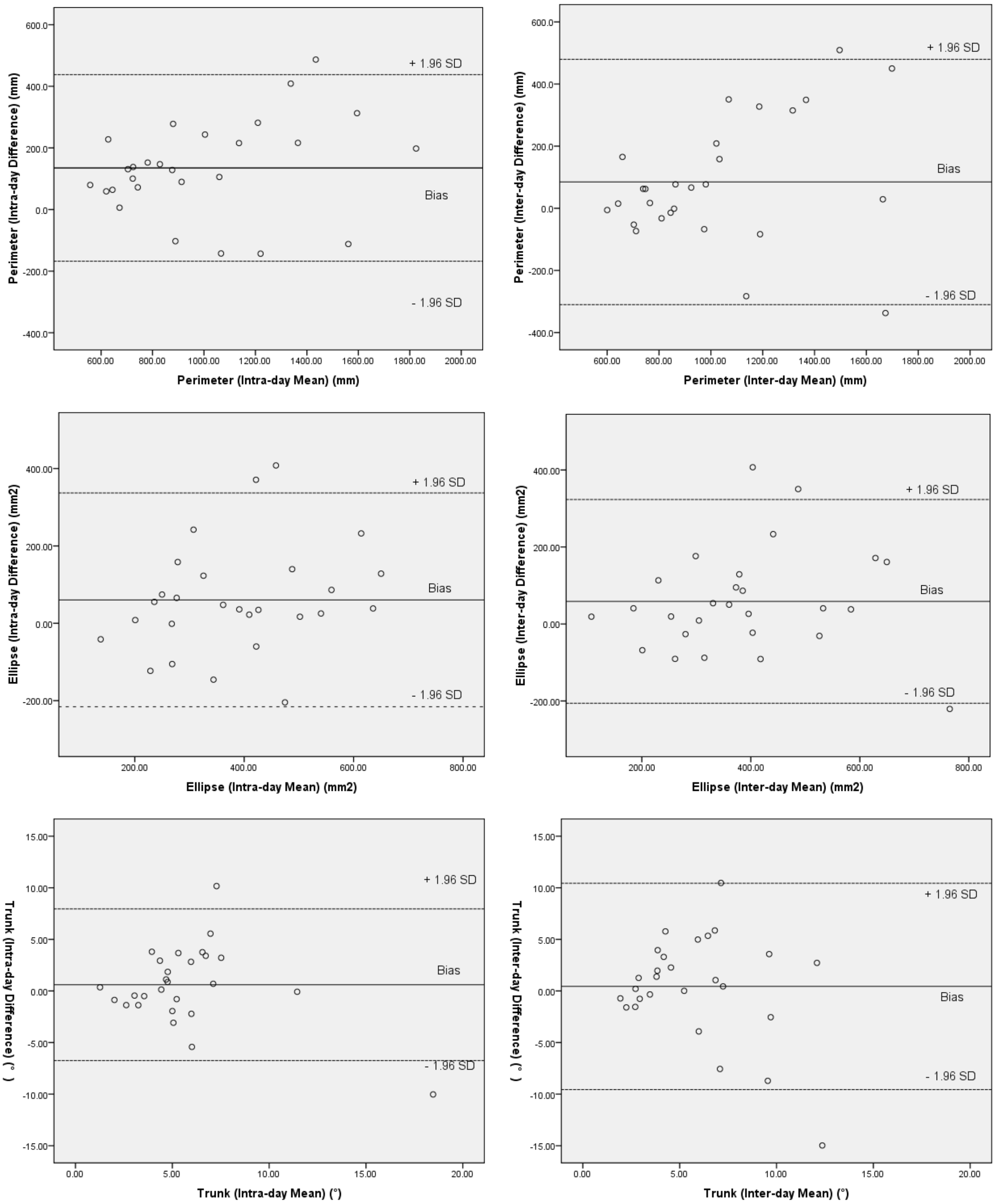

Figure 3: Bland-Altman-Plots for Perimeter, Ellipse, and Trunk displaying intra- and interday variability. Individual subject differences between the tests are plotted against the respective individual means.

Concerning the perimeter there is a bias of 134.85 mm for the intra-day session, which stands for better results in the second session, the limits of agreement are -168.0 to +437.7 mm. With regard to the inter-day session the bias is slightly reduced to 84.79 mm, with a wider range of the limits of agreement from -310.0 to 479.6 mm. The ellipse shows a bias in the intra-day measurements of 60.49 mm^2, the limits of agreement are -215.8 to 336.8 mm^2; the inter-day measurements display a bias of 58.6 mm^2, with limits of agreement from -206.0 mm^2 to +323.2mm^2. Finally, the trunk measures show only a slight bias of 0.6° for the intra-day sessions and 0.4° for the inter-day sessions, standing again for better values in the second and third sessions, respectively. The limits of agreement lie between -6.8 to 8.0° for intra-day variability and -9.6 to 10.4° for the inter-day variability.

Discussion

The aim of this study was to assess the reliability of a new stabilometry system, the Pro-Kin Type B line system (TechnoBody™) and to quantify intra- and inter-day variability. First of all, the within-subject reliability was assessed, analysing the variability of three consecutive trials within one testing session. This was done for three sessions. The coefficients of variance (CV) as well as the RMSE show the highest variability in the first session, indicating that the persons have to get used to a new task, e.g. standing one-legged on a dynamic platform. Variability is decreasing in the second session and again slightly increasing in the last session (after one week time-lag). The better values (lower variability) could be possibly explained on a neurological background. It could be assumed that the subjects try to adapt the neurological system and save the problem/task in a specific movement pattern. Overall, for all three variables the subjects showed a rather high variability. This could be due to the fact, that the advised task is quite difficult to solve, even for trained and young persons.

For the intra- as well as the inter-day reliability significant differences for the perimeter and the ellipse between the respective sessions were found, indicating a better stability in the second and third session. Thereby the perimeter was mostly affected, especially in the intra-day variability. Significant differences were not evident for the trunk measures. The latter is probably due to the fact that there is higher within-subject variability in the trunk motion.

The Bland-Altman-Plot illustrates the bias and agreement of the test-retest situation. The next step is the interpretation of the limits of agreement. Some researchers (deJong et al. 1996) have concluded acceptable measurement error by observing that only a few of the test-retest differences fall outside the 95% limits of agreement. In our results only 1-2 subjects out of 27 are beyond these limits for all the observed variables indicating good reliability of the measurement instrument. However, this interpretation was criticised by Atkinson et al. 1998 who postulate to interpret the limits regarding the practical use. In the recent study the limits show a wide range for both intra- and inter-day differences, which have a clear effect for the interpretation of the results. Muehlbauer et al. 2010 showed similar results with even a slightly wider range of the limits of agreement in the test-retest variability declaring an excellent intra- and intersession reliability. That study can be directly compared to the recent one since testing procedures were completely adapted.

In conclusion, the tested task – one-legged standing on a dynamic platform – is until today very rarely used and investigated. Most of the previous studies used a static and mostly bipedal task (e.g. Romberg-Test) to assess the stability of a person and/or patient. For the use in a sportive population a more challenging test has to be applied to assess differences within this population. Therefore this test is practical in use. On the other hand a quite high variation in performing this task was found which is also due to the difficulty of the task. Nevertheless, a good reliability was found for all variables indicated by the Bland-Altman-Plots. However, this study was conducted on a rather homogenous sample of young and sportive people. Therefore, the results should be verified on a wider range of people, including for example elderly and children, injured, disabled or neurological patients to assess the variability for this population and probably get indications to adapt the testing protocols or device settings.

In addition, further studies should focus on the validation of the instrument and the testing protocol using similar test devices and/or balance tasks. This can help to improve the testing protocol on one side but also the interpretation of the results on the other side.

Practical Applications

Based on the results, both high within-subject variability as well as a high intra- and inter-day variability in the testing was observed. Based on this information test protocols in the daily routine in a clinic have to be adapted, e.g. using the test trials before recording the valid trial, calculating a mean value of three trials or using the best out of three trials. Knowing the variability of the subjects in performing this task as well as being aware of the reliability of the system is indispensable for the interpretation of test results in the clinical daily routine.

Literature

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Suggestions for Journals for Publications:

Journal of Athletic Training / Scand J. Med Sci Sports / Clinical Journal of Sports Medicine / Sportverletzung – Sportschaden / Journal of Physical Therapy / Archives of Physical Medicine and Rehabilitation

Other preferred journals?